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ABSTRACT

This report contains the following white papers commissioned for the Forum on the Future of Technology in Education: Envisioning the Future to explore a variety of perspectives related to the future of technology in education, as well as the topics of "e-learning" and technology and disability: (1) "Technology in K-12 Education: Envisioning a New Future" (David D. Thornburg); (2) "Extracurriculars as the Curriculum: A Vision of Education for the 21st Century" (Roger C. Schank and Kemi Jona); (3) "Rewiring the History and Social Studies Classroom: Needs, Frameworks, Dangers, and Proposals" (Randy Bass and Roy Rosenzweig); (4) "Forum on Technology in K-12 Education: Envisioning a New Future--Science" (Steven J. Rakow); (5) "Technology Meets Math Education: Envisioning a Practical Future Forum on the Future of Technology in Education" (Andee Rubin); (6) "The Future of Technology in K-12 Arts Education" (Joan Assey); (7) "Toward a Vision of the Future Role of Technology in Literacy Education" (Linda Labbo); (8) "E-learning: Education Businesses Transform Schooling" (Peter J. Stokes); and (9) "The Future Is in the Margins: The Role of Technology and Disability in Educational Reform" (David Rose and Anne Meyer). The document also contains an agenda for the forum, a summary report, participant biographies, and a discussion of emerging priorities identified during the forum. (MES)

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Forum on Technology in Education: Envisioning the Future. Proceedings (Washington, D.C., December 1-2, 1999)

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- Your Comments
- Introduction
- Forum Report
- White Papers
- Forum on Technology in Education
- Emerging Priorities
- '96 ET Plan

Forum on Technology in Education: Envisioning the Future

In recognition of the opportunities afforded by the effective use of technology in education, the Office of Educational Technology (OET) has undertaken a strategic year-long review and revision of the national educational technology plan. The first steps in this process included the commissioning of several white papers in the fall of 1999 on the future of technology in education. In December 1999, a two-day meeting – *The Forum on Technology in Education: Envisioning the Future* – convened a variety of experts to explore the implications of the white papers and to engage in interactive exercises designed to explore the most promising future roles of technology in education.

Forum Report—The summary report synthesizes the themes that emerged from the two day Forum.

White Papers—Several white papers were commissioned to help inform and guide conversations related to the future use of technology in education during the Forum.

Agenda—The Forum consisted of two intense days of presentation, discussion, and synthesis of ideas.

Participant Biographies and Participant Affiliations—Forum participants included a dynamic group of educators and students, technology futurists, content area experts, business and government representatives, and others.

Emerging Priorities—Originally identified by participants at the Forum, these issues are likely to be pivotal in any successful effort to increase the effective use of technology in education.

Also, click here to view the graphical notes taken during the Forum

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Introduction | Forum Report | Forum White Papers | **Forum on Technology in Education** |
Emerging Priorities | Comment Here | 1996 National Educational Technology Plan

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- '96 ET Plan

Report on the Forum on Technology in Education: Envisioning the Future

Participants at the Forum explored technology trends and their implications for education toward the end of identifying new national priorities for technology in education. This report summarizes activities at the Forum, as well as several white papers prepared to inform discussions.

Click here to view Report on the Forum on Technology in Education: Envisioning the Future in pdf format.

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Also, click here to view the graphical notes taken during the Forum

Introduction | **Forum Report** | Forum White Papers | Forum on Technology in Education | Emerging Priorities | Comment Here | 1996 National Educational Technology Plan

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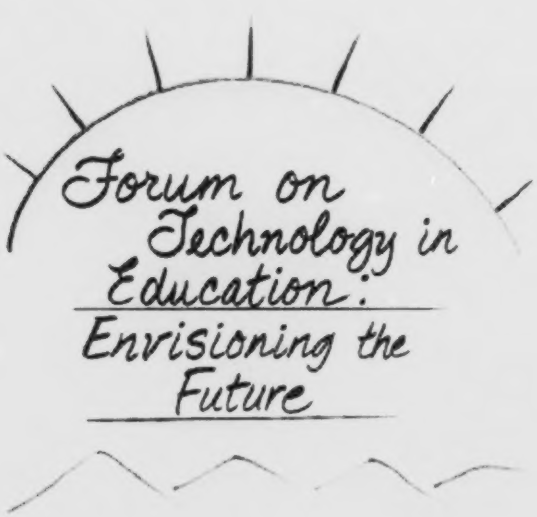
FORUM ON TECHNOLOGY IN EDUCATION: ENVISIONING THE FUTURE

PROCEEDINGS

DECEMBER 1-2, 1999
GEORGETOWN UNIVERSITY CONFERENCE CENTER
WASHINGTON, DC


Forum on Technology in Education:
Envisioning the Future

A WORKING MEETING SPONSORED BY THE OFFICE OF EDUCATIONAL TECHNOLOGY
U.S. DEPARTMENT OF EDUCATION

FORUM ON TECHNOLOGY IN EDUCATION: ENVISIONING THE FUTURE

PROCEEDINGS

PREPARED FOR:
OFFICE OF EDUCATIONAL TECHNOLOGY
U.S. DEPARTMENT OF EDUCATION

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THIS REPORT IS A SUMMARY OF THE *FORUM ON TECHNOLOGY IN EDUCATION: ENVISIONING THE FUTURE.* IT DESCRIBES POINTS RAISED BY FORUM PRESENTERS AND PARTICIPANTS, AND SHOULD NOT BE CONSTRUED TO REPRESENT THE VIEWS OF THE U.S. DEPARTMENT OF EDUCATION. THE OPINIONS PRESENTED ARE INTENDED TO STIMULATE FURTHER THINKING AND CONTINUED DISCUSSION ABOUT THE FUTURE OF TECHNOLOGY IN EDUCATION.

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FORUM ON TECHNOLOGY IN EDUCATION: ENVISIONING THE FUTURE

INTRODUCTION

In recent years, interest in increasing the use of technology in education has catapulted to national prominence. This interest has been spurred by the widespread recognition of the transformations technology is having on the American economy, as well as by the potential for technology to transform the teaching and learning experience. Coupled with dramatic increases in the availability and use of technology in elementary and secondary schools, there is a growing sense that there now exists a critical mass of opportunities to make tremendous strides in improving the nation's schools.

In recognition of these opportunities, the U.S. Department of Education's Office of Educational Technology (OET)—charged with providing leadership and direction to the U.S. Department of Education's educational technology initiatives and with developing policy—has undertaken a strategic year-long review and revision of the national educational technology plan, *Getting America's Students Ready for the 21st Century: Meeting the Technology Literacy Challenge*. The first steps in this strategic process included the commissioning of several white papers in the fall of 1999 on the future of technology in education, including:

- *Technology in K-12 Education: Envisioning a New Future* by David Thornburg, which calls for deep systemic changes in elementary and secondary education as a consequence of two central ideas: (1) that how we use technology in education is more important than if we use it at all, and (2) that unless our thinking about education is transformed along with increases in the use of technology in our classrooms, our technology investments will fail to live up to their potential;

- *Extracurriculars as the Curriculum: A Vision of Education for the 21st Century* by Roger Schank and Kemi Jona, which calls for the fundamental reshaping of the American educational system including establishing new roles for teachers, new roles for schools, and the centralization of curriculum and instructional development;

- *Rewiring the History and Social Studies Classroom: Needs, Frameworks, Dangers, and Proposals* by Randy Bass and Roy Rosenzweig, which helps identify the opportunities to use technology to make the social studies classroom a site of active learning and critical thinking through inquiry-based learning, bridging reading and writing through on-line interaction, and making student work public in new media formats;

- *Forum on Technology in K-12 Education: Envisioning a New Future—Science* by Steven Rakow, which explores the realities and possibilities of instructional technology applications in science education—from the "Global Classroom" to the "Technologically Enhanced Classroom";
- *Technology Meets Math Education: Envisioning a Practical Future* by Andee Rubin, which describes many of the ways that technology can help create communities of learners in which students actively engage in the process of mathematical sense-making;
- *The Future of Technology in K-12 Arts Education* by Joan Assey, which speaks to the essential nature of using technology in arts education and the linkage between learning and technology; and,
- *Toward a Vision of the Future Role of Technology in Literacy Education* by Linda Labbo, which suggests how technological innovations are likely to play a role in literacy education, explores the concept of digital literacy, and describes likely new tools for teachers.

In December 1999, a two day meeting—*The Forum on Technology in Education: Envisioning the Future*—was convened to provide an opportunity to explore the implications of these white papers and to engage in interactive exercises designed to explore the most promising future roles of technology in education. Participants included a dynamic group of educators and students, technology futurists, content area experts, business and government representatives, and others (including the white paper authors). Aided by a carefully constructed agenda and a GroupWare application running on laptop computers[1], an experienced graphics facilitator supported the interactions of participants and pushed them to make new connections—all to the end of identifying emerging priorities that could lead to new national goals for the use of technology in education.

This paper serves as a synthesis of the main ideas arising from the Forum. It incorporates reproductions of notes taken during the meeting, as well as summaries of participant comments submitted via GroupWare. Appended to the summary are the Forum agenda and the list of participants. The white papers commissioned for the initiative are available at OET's website: http://www.ed.gov/Technology. The paper concludes with a brief description of the next steps to be undertaken by OET in their process of reviewing and revising the national educational technology plan.

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[1] The GoupWare application allowed participants to quickly and anonymously contribute their thoughts, feelings, and opinions at specific times during the meeting, as well as to read the comments of other participants.

A FUTURE DIFFERENT FROM OUR PAST: IMPLICATIONS FOR EDUCATION OF EMERGING TECHNOLOGIES AND TRENDS

The Forum opened with a consideration of the pace and breadth of technological change in recent years, emerging technological trends over the next ten years, the intersection of those trends, and potential implications for education. Indeed, what was most striking to participants was the increasing pressure on schools to adapt to a society in the midst of dramatic change. As one participant noted:

> *"The pace and breadth of technological change is hard to reconcile with the very traditional organizational structure of schools. Combined with the increasing infrastructure to support the involvement of folks outside the school staff in education, this suggests increasing pressure to involve multiple sources of information, coaching, and expertise in K-12 education. Not to do so would risk making education increasingly irrelevant in the lives of students, particularly at the middle and secondary school levels."*

Opening remarks by Marshall "Mike" Smith, Acting Deputy Secretary of Education, all but challenged education policymakers and practitioners to join the technological revolution: "As a mentality, as an orientation, as a big idea, technology has swept the nation in almost every sector, and I say that with the exception of education." Among the many technological trends with the potential to affect education in the coming years, he emphasized three:

> **"The fundamental issue is whether to push for the existing educational system to assimilate technology or whether to pose the problem as needing to accommodate to the demand for inquiry, collaboration and public accountability and offer technology as a possible means to do this."**
> **– Forum Participant**

(1) universal accessibility to computing devices and the Internet, which will be made possible through small, portable, and inexpensive devices currently under development;

(2) dramatically faster access to information, through increases in bandwidth and computing power; and,

(3) increased private sector involvement in delivering technology, information, and applications to education.

The implications of these three trends, he asserted, are enormous and will result in nothing less than the unleashing of space, time, and competition in education.

Through visual maps of predicted technology trends and their intersections over the next ten years, Mary O'Hara Devereaux of the Institute for the Future asked participants to consider the likelihood of changes to society that some would consider being straight out of science fiction novels. While she would be the first to admit that the future of technology could take many paths, she and her colleagues at the Institute for the Future have defined four primary pathways of technological advances: information and communication technologies, biotechnology, material sciences, and energy science. Some of her examples included: dramatically increased life spans and quality of life through biotechnology advances, ubiquitous sensors linked to networks that would allow technology to adapt to the needs of its users—even before those needs were made known, and the ability to move "off the grid," allowing us to access information and services from anywhere at anytime. While her presentation spurred participants to consider future scenarios of which they had never even conceived and their implications for education, she also cautioned participants that social, economic, political, and demographic trends will influence technological trends in unpredictable ways: "Never mistake a clear view for a short distance—you can see a path, but the path is fraught with difficulties and not as fast as people may think."

> "As we move from an age of information to an age of creativity, are our schools prepared to meet this challenge? Education, as a system, has been resistant to change and, often, limited in its creative vision. We barely understand information—how well do we understand creativity?"
> – Forum Participant

In the context of thinking about broad technological changes in society and their implications for education, David Thornburg challenged participants to examine many of the assumptions about the current organization and structure of education that, in his view, simply no longer serve a useful function:

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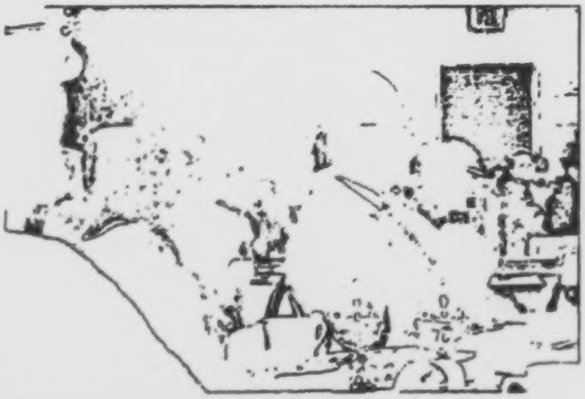

> ***"As we complete the twentieth century and prepare for the twenty-first, it is important to realize that our world is far different from the one which existed a hundred years ago. In the 19th century, a largely agrarian workforce existed alongside an emergent industrial economy powered by muscle, water, and steam. Since the turn of this century, we have had the flight of airplanes, commercial radio broadcasts, television, the invention of modern computer technologies, the emergence of new sciences (e.g., bioinformatics, chaos, and complexity) and a continued rapid increase in the development of new information in a myriad of fields and endeavors."***

For instance, he takes to task the fact that education is currently a system based on a fixed number of class periods and school days during which students are expected to master a predetermined body of knowledge and acquire certain skills. This time dependent system, he asserts, is in essence a filtering system—one that separates those who learn quickly from those who do not. Rather than address the needs of each learner, we label some children as "slow learners," and relegate them to the "scrap heap of society." The folly of this approach, he points out, is that at the same time as we allow schools to act as filtering systems for our children, we are moving to recognize the vital importance of adults to engage in lifelong learning—a flexible approach to acquiring skills and knowledge on demand, at the time and place of one's choosing. In essence, he argued that no matter what role technology would play in the school of the future that "we must prepare learners for their future, not for our past."

"The rethinking of the curriculum—what is worth learning and better ways to learn it and measure its learning—is central. Better learning goals, methods, and measures are central and the delivery medium (real or virtual) is secondary."
– Forum Participant

Roger Schank, reinforcing and extrapolating the comments of David Thornburg, called for the controversial and wholesale abandonment of what, in his view, is an antiquated educational system. The new system he envisions will be enabled by the universal availability of on-line courses that will remove from teachers and schools the responsibilities for teaching academic subjects and allow students to determine their own success by completing tasks individually at their own pace:

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> *"Instead of teaching academic subjects, teachers and schools will focus on combating the increasing social isolation that our society will face. Schools will become activity centers where students work in groups on real-world projects, go on trips, and participate in the community. While students may also use schools as locations to engage in on-line course work, this course work will be just as available at home."*

He asserts that one key implication of his view is that curriculum and instructional development must be centralized. Only through centralization will we be able to realize the tremendous efficiencies of developing top-quality courses once, rather than having every teacher in the country repeatedly doing lesson plans for the same courses: "The fiction of local control of education will become evident and a panel of experts instead of local groups of well-meaning, but uninformed, parents will develop the curriculum."

"What does local choice mean in a ubiquitous pool of alternative learning opportunities when each parent and each teacher can 'kick the tires' of each potential learning resource at a micro-level (day by day; hour by hour)? What is the national role? Perhaps to assure high quality options, to assure options for 'special students,' to assure options aimed toward major national needs?"
– Forum Participant

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ADVANCING MASTERY OF CONTENT THROUGH TECHNOLOGY

A major focus of the *Forum on Technology in Education: Envisioning the Future* was to explore the intersection of technology and content. Indeed, at the same time that technology is creating pressures on the organization and structure of schooling to change, it also is enabling the acquisition of student knowledge and skills in new and more powerful ways. In addition, participants recognized that technology is re-defining the content areas. Consequently, considerations of white papers commissioned about the future of technology in each of the major content areas (social studies, science, mathematics, arts, and reading/language arts) occupied a great deal of participant attention.

> **"There is an under-emphasis in our discussions of the need for 'integrative knowledge' to be one of the key forces driving an educational reform process. The integration of content, pedagogy, and technology (in the broadest sense of new learning environments)...both within traditional and in new fields, and across subjects and fields, is a critical place for reform or revolution."**
> **– Forum Participant**

In their own ways, each of the content experts who authored a white paper offered their own reasons for believing that the use of technology is beneficial in advancing teaching and learning in their discipline. Importantly, though, there was a striking convergence of ideas about what all teachers desire in their classrooms regardless of content area or level:

- Teachers want their students more engaged in learning;
- They want their students to construct new and better relationships to knowledge, not just represent it on tests; and,
- They want their students to acquire deeper and more lasting understanding of essential concepts.

Below, examples of some of the powerful opportunities afforded by technology are summarized for each of the major content areas explored during the Forum.

SOCIAL STUDIES

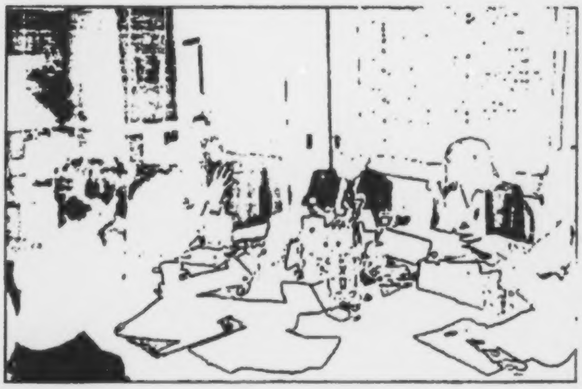
Randy Bass and Roy Rosenzweig highlighted in three broad categories some of the most successful educational uses of technology in social studies:

- **Inquiry-based learning** utilizing digitized and multimedia primary sources available on CD-ROMs and the World Wide Web, involving different senses and forms of expression and addressing different learning styles. Probably the most important influence of the availability of digital materials and computer networks has been on the development of inquiry-based exercises rooted in the retrieval and analysis of primary and cultural documents. These range from simple Web exercises in which students must find a photo that tells something about "work" in the late nineteenth century to elaborate assignments in which students carefully consider how different photographers, artists, and writers historically have treated the subject of poverty.

- **Bridging reading and writing through on-line interaction,** extending the time and space for dialogue and learning, and joining literacy with disciplinary and interdisciplinary inquiry. One very significant dimension of "making thinking visible," is the bridging of reading and writing through on-line writing and electronic dialogue. The emergence of electronic mail, electronic discussion lists, and Web bulletin boards can support and enhance such pedagogies by creating new spaces for group conversations. To take one simple example, *Postcard Geography* is a project, organized through the Internet, in which hundreds of classes (particularly elementary school classes) learn geography by exchanging postcards (real and virtual, purchased and computer generated) with each other.

> "The best courses will be developed with "experts" on content and teaching...AND with students...take a look at the latest round of THINKQUEST modules that were developed by TEAMS of students who found each other on-line and come from more than one country."
> – Forum Participant

- **Making student work public in new media formats,** which encourages the exchange of knowledge-representations and creates opportunities for review by broader professional and public audiences. New technology—particularly the emergence of the Web as a "public" space that is accessible to all—has greatly leveraged the advantages of public presentations of student work. For example, at an elementary school in Virginia, fifth graders studying world cultures build a different "wing" of a virtual museum each year, researching and annotating cultural artifacts, and then mounting them on-line.



SCIENCE

Steven Rakow asserted that the true potential impact of instructional technologies on K-12 education would be to enhance the classroom of today by applying technology to create what he termed "The Global Classroom" and "The Technologically Enhanced Classroom."

- **The Global Classroom** opens the walls of the classroom to provide students access to a plethora of information and opportunities. For instance, to address the fact that with the rapid advances in science, textbooks were out of date as soon as they left the presses, the *sci*LINKS project was started. *Sci*LINKs symbols are now found in science textbooks in certain topic areas. By keying in a code number, students, teachers, or parents can access a relevant, up-to-date, age appropriate website that has been reviewed by a panel of science educators. Another web site, The Virtual Field Trip Site, is dedicated to providing teachers with access to information and pictures from areas and events that they might not be able to physically visit or see, such as deserts, hurricanes, oceans, salt marshes, tornadoes, and volcanoes.

- **The Technologically Enhanced Classroom** extends human capabilities by providing teachers with the time and opportunity to enrich their instruction. New technologies, such as CD-ROMs and robotics, have provided incredible resources for teachers. Other technologies employed by science classes are microcomputer-based laboratories that provide a wide range of probes, including pressure, EKG, alpha waves, heart monitors, conductivity, sound, and motion detectors, to name just a few. These probes, along with the supporting software, allow students to collect, display, and analyze vast quantities of data over time periods ranging from seconds to days.

MATHEMATICS

In mathematics, Andee Rubin described five types of opportunities afforded by technology (including computers, calculators, the Internet, and associated input and output devices):

- **Dynamic connections.** For many students, the lack of visual representation in mathematics makes it difficult to make connections between a mathematical expression and the situation to which it refers. Computers—which can draw graphs and other mathematical objects and allow students to "play" with them—can help students relate mathematical expressions to images in the "real" world. One way these connections can be made is with digital cameras; no longer are the pictures we take static objects, but as digital objects they take on a new life that enables them to be closely linked with mathematical representations. For instance, CamMotion provides tools to analyze motion as it is captured on a video camera and to create the corresponding graphs of changes in position or speed over time. Since the video and the graphs are linked, when the student points with the mouse to a point on the graph, the corresponding frame of the video is displayed.

- **Sophisticated tools.** Exploratory data analysis software (and other visualization techniques) allow students to see patterns in data they would never glimpse if they had to do the calculations or even draw the graphs themselves—emphasizing the meaning of mathematical objects and the beauty of the patterns they exhibit. One such tool is Fathom, a sophisticated tool that provides students with many ways to look at—and therefore understand—complex databases.

- **Resource-rich mathematical communities.** Creative uses of the Internet allow for the creation of virtual communities in content areas. The best known of these is the Math Forum site, which includes a large list of (screened for quality) resources for K through college math teaching, including interactive activities; recommendations of software; examples of classroom activities and links to related discussion groups; a

> "[These are the]...critical criteria teachers have for any classroom technology: Will it help kids learn? Is it reliable? Is it flexible? Do I have to fix it if it is broken? How much do I have to invest in learning it?"
> – Forum Participant

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conversation space for teachers; an extensive math library; an Ask Dr. Math feature, in which an expert answers students' questions; Problems of the Week at a variety of levels of difficulty; discussion groups on topics, such as discrete math and a multi-lingual discussion on the history of mathematics; and, a showcase that highlights recently added material. This site has served as an important portal for mathematics educators and as a kind of social center for the mathematics education community.

- **Construction and design tools.** The increasing power and versatility of computers makes possible uses that are dramatically different than previously available—uses rooted in "constructionism." Its roots are in the LOGO community; LOGO is a powerful yet accessible programming language in which it is particularly easy to create pictures, animations, and simple robot command sequences. Programming in LOGO incorporates math explicitly at times, but also introduces students to more general mathematical concepts such as iteration and recursion. For instance, in one recent project, students designed and programmed computer games that would teach other students about fractions.

- **Tools for exploring complexity.** For mathematicians, one of the most important developments in technology has been the increased number of tools for dealing with complexity. From Mathematica, a general algebraic tool, to specific modeling systems (e.g., Agent Sheets) to specifically designed languages for exploring large-scale parallel models (e.g., Star LOGO), areas of mathematics that had previously been off-limits for almost everyone are now accessible to students as well as mathematicians. One type of investigation made possible by such tools is simulation.

ARTS

Arts education means using the aesthetic symbols of music, theatre, visual arts, and dance to give our humanity form and meaning: music uses notes, theatre uses storytelling, the visual arts use images, and dance uses body movements. Students are thus able to create, perform, and respond to the arts. According to Joan Assey, technology as a tool in arts education can assist students and teachers as they incorporate overwhelming amounts of information related to these symbol systems. Each area of arts education can be augmented by technology:

> "I think the main beauty of technology in the arts is that it allows those who do not have virtuosity to actually compose music, choreograph dances, create a digital orchestra, design graphics/visual arts through the assistance of synthesized sound/images/ notation. It allows those who do not or cannot read music (like myself) to experiment and create musical scores, discover and share my own voice through digital storytelling. That's powerful."
> – Forum Participant

- **Music:** Electronic keyboards are being used as classroom instruments and computers are being used for creating and composing music in many classrooms today.

- **Theatre:** Video technology and various software applications are available to assist the theatre experience by offering both teachers and students choices to improve the delivery of the curriculum. Video technology can capture students' participation in theatre.

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Software can help with set design, costuming, computerized lighting and sound control boards.

- **Visual Arts:** Digital technology has become a vehicle of creative expression as well as a source for arts. Electronic drawing, computer animation, video digitizing, and multimedia activities are parts of many art classes that have integrated technology.

- **Dance:** Technology can be used in dance to document and analyze the dynamics of movement. For example, computer-aided choreography gives dance educators the ability to work out ideas of space and movement on screen without bringing the dancers together. Computer software created as a movement notation system allows teachers and students to create and edit dance notation scores very quickly.

READING/LANGUAGE ARTS

In anticipation of changing social literacy expectations, Linda Labbo described, not so much the ways in which technology is enhancing, but changing, the teaching of reading and language arts. These expectations include:

- **Forthcoming Definition of Digital Literacy.** The penetration of digital reading and writing into all aspects of daily literacy activity has increased and will ultimately have a profound effect on what is considered mainstream reading and writing in the very near future. For example, when many Americans want to write a quick note to a colleague, they compose and immediately send it via e-mail on a computer screen. The note will be sent in the same amount of time to a computer in an office across the hallway as it will take to send it to a computer in an office across the ocean. When someone decides to find out the latest international news, he accesses an on-line news service and downloads video clips, audio commentary, or printed news columns on his computer screen. When someone decides to write a report, she is more likely to draft, revise, and edit it on a computer screen with a word processor than with a pen and paper. In these instances, the computer is more than a typewriter or publishing instrument, it is a tool for composing that allows the author to encounter and manipulate ideas on the computer screen.

- **Formulating Relevant Learning Theories.** It is possible that digital literacy is so complex that it will require multiple theoretical underpinnings. Imbedded in appropriate learning theories are social learning strategies that will be crucial to children's literacy development because social collaborations, such as group learning among Internet project participants, help prepare them for future workplace organizational/decision-making frameworks.

- **Supportive Digital Environments.** In recognition of this context, children in the near future who have difficulties comprehending text will have supportive digital environments on screen that allow them not only to read text, but have access to video clips of conceptual constructs (e.g., an orbiting planet), definitions of specialized vocabulary (trajectory), links to other textual references (an interactive encyclopedia of the solar system), additional background knowledge (a narration about why it is important to learn about planetary orbits), pronunciations of unknown words, or a mini-lesson that may be tailored to help a child learn how to sound out an unknown word (a voice prompt "If you know that J-a-n-e-t is Janet, then pl-a-n-e-t would be … planet.").

TOWARD ESTABLISHING A VISION FOR THE FUTURE OF EDUCATION AND TECHNOLOGY

In considering the information presented during the Forum, participants had an opportunity to identify trends and forces, assumptions, concerns, and opportunities pertinent to establishing a vision for the powerful use of technology in education. In so doing, many participants expressed that while we may have a good sense of what is possible at the classroom level in a vacuum, much work still remains in identifying strategies to encourage sustained institutional change at the national, state, and local levels.

A Need for Radical Reform or Incremental Change?

One of the notable conversations during the Forum directly addressed the apparent value conflicts over the purposes of technology in schools, its uses, and impacts—debating whether technology should assist with a radical re-organization of the structure of schooling or with more modest, incremental reforms. Participants thought it necessary to make explicit these value conflicts before a meaningful vision for the future of technology in education could be established.

> "I was relieved at the end of the session yesterday that some of us recognized explicitly that there were deep value conflicts over the purposes of technology in schools, their uses, and their impact. It is precisely these conflicts over values that have to be made explicit before we can come to any agreement over national goals for schools."
> – Forum Participant

On the one hand, some participants asserted that the organization and structure of schooling is fundamentally flawed, essentially agreeing with the propositions advanced by David Thornburg and Roger Schank. Arguing that the future of education should not simply be an extrapolation of the past, they pointed to examples of how poorly the educational system is aligned with the requirements of being a citizen and worker in today's technologically rich society. Not only are new generations growing up with fundamentally different

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perceptions of what is normal, technology provides new opportunities for learning far beyond what was thought possible even a few short years ago.

Many of the opportunities these participants saw address current critiques of the education system. For instance:

- **Curriculum and course development.** A rethinking of the core curriculum is long overdue. This rethinking must address the underlying assumption that knowledge (as in educational content) remains static while everything else, including new discovery knowledge changes around it. In so doing, we should examine what is worth learning, what better ways exist to learn it, and how to measure progress in learning. In addition, the best courses should be developed with "experts" on content and teaching *and* with students.

> "The technology in our schools should be equal to the newest technologies in our markets. When we choose to develop new technologies, our students and teachers should have access so that we continue to go forward and improve. Our technology trends will come to a halt without the education of the next generation."
> – Forum Participant

- **Availability of learning tools.** We have been constrained by the power of our learning tools. New tools—enabled by innovations in software and learning environment design—give us a chance to create rich and diverse learning resources, such as graphic and simulation tools, that are fully accessible to all. These tools offer us the first real possibility of reaching students who heretofore have been failed by our schools.
- **Quality control.** Technology enables us to imagine ways of assessing the quality of an educational experience on a national, or even international, scale—allowing a parent to know how well their child's educational program compares to the best available.

> "The organization of school will be difficult to change. Ultimately, we need to think about new ways of assessing and documenting competence, much of which may be supported by technology in order to free up educational organizations and structures to try new methods to meet the goals of education. This will be a technology-based, more far ranging version of the current exchange of flexibility for accountability seen in charter schools."
> – Forum Participant

On the other hand, other participants saw much that works with the current education system, rejecting characterizations of an antiquated, irrelevant institution. These participants tended to be wary of the promises made about the ability of technology to solve social and political problems and were quick to assert that meaningful change could come only from within the system. While they certainly recognized many of the ways in which technology could enhance the ability of schools and teachers to serve students, they were decidedly pragmatic about the speed and scope of any dramatic changes. For instance, some asserted that there already exists some consensus regarding what the future of technology in education holds: preservice education focused on content; professional development centered on teachers; development of tools and filtering mechanisms aimed at allowing teachers to make better use of the resources of the digital world; research and assessment that brings teachers into the process; and, a reconsideration of standards and assessment in ways that don't stifle innovation.

FOSTERING CHANGE

Importantly, some participants saw the choice of options for the future presented by the "radical reformers" and the "incrementalists" as a false dichotomy, emphasizing the danger in misleading stakeholders of all levels. Recognizing the importance of the social context of technology use, these participants advocated the establishment of a hybrid approach—one that encourages incremental improvements at the same time as it supports innovation—as the true opportunity.

> "I think there is something fundamental missing in what we've heard so far—and that is an acknowledgement that there are things that work well, there are students who learn a lot and teachers who teach well in analog environments. That is not a luddite comment. Just a notion that we're not starting from a pile of ashes."
> – Forum Participant

That being said, each of the participants also came away with a heightened awareness of some of the organizational and structural constraints facing those seeking to improve education. Interestingly, participants asserted that one of the most basic and conspicuous of these constraints is our own collective imagination about what the future of education could hold: the public images of education and the ways in which local school boards and policymakers envision the organizational structure of education of all levels are stifling innovation and creating barriers to change.

In this regard, participants provided some examples of current barriers to change in terms of how schools are currently organized and structured. For instance, one participant noted that we are constrained by the fact that we have to teach collectively and indoors. Another pointed to the obsession with the "course" as a semester or quarter entity, which has continuously shrunk from a "course of study" to a year long course to a 10-15 week marking period. Other barriers to change discussed by Forum participants included:

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- A fear of change coupled with what some participants termed "techno-resistance" (i.e., an unwarranted fear of automation);
- A narrow definition of school and a lack of consideration of the purpose of education;
- Inequitable access to and use of technology along a variety of lines, including economic, racial/ethnic, and gender (i.e., the "digital divide");
- The need to demonstrate the "value-added" of technology use in schools, while that use is still in a formative stage;

> **"As we move from an age of information to an age of creativity, are our schools prepared to meet this challenge? Education as a system must increase its creative vision and embrace change."**
> **– Forum Participant**

- The imposition of accountability systems that stifle innovation, stress breadth of content coverage, and do not pick up the kinds of skills and habits of mind needed now and in the future;
- Teachers who feel ill-prepared to use technology in conjunction with systematic lack of support for teacher professionalism, including the lack of supported (paid for) time in the teacher's day for (teacher) learning, planning, and collaboration;
- The lack of a critical mass of technology in schools to really make a difference;
- The initial and ongoing expense of acquiring, maintaining, and upgrading technology; and,
- The lack of availability of high-quality software and other resources on the Internet connected to state and local content standards, coupled with a fragmented market that does not reward necessary research and development.

In the end, though, despite the barriers to change discussed by participants, there was broad agreement that technology should and must play a central role in the future of education. And, in this era of economic prosperity, participants agreed that now is the time to make a strong commitment to the future by challenging the nation to take bold action in hastening the coming of the future of education.

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EMERGING PRIORITIES

"People tend to overestimate the impact of new technologies in the short run, and underestimate their long-term impacts."

– Mary O'Hara Deveraux

The Forum concluded with the identification of emerging priorities that the U.S. Department of Education—in collaboration with other Federal agencies, state and local governments, the private sector, and others—should address through goal setting or other national leadership activities. In so doing, participants emphasized the need to:

- Eliminate the digital divide by ensuring that all students and teachers have access to computers and the Internet, be technologically literate, and know how to effectively use the technology.
- Support traditional school improvements with technologies in mainstream public schools while also providing incentives for experimentation and radical systems change.
- Foster innovation at the national level to help set a context that supports breaking down old, irrelevant, and unproductive ways of managing and supporting education in the nation's school districts.
- Improve the linkage between local policies and practices and state and national policies and priorities—emphasizing dissemination of all aspects of local technology-based initiatives from adoption to implementation to outcome assessment.

"The fact that we still can identify a 19th classroom as a school may be a good example of form dictating function. Have we, as educators, been limited in our vision of the possibility by the form of the current reality?"
– Forum Participant

The specific priorities identified by participants included:

1. **All students and teachers will have ubiquitous access to state-of-the-art information technology in their schools, classrooms, communities, and homes.** Participants were unanimous in their agreement of the importance of providing universal access to technology for teaching and learning. Much of the promise of the use of technology in education, including the notion of fostering learning anytime anywhere, hinges on ubiquitous access to learning tools for students *and* teachers and on how they are used. In addressing this issue, participants stressed the importance of paying attention to individual learner characteristics and needs, as well as the social context of using technology.
2. **All teachers will effectively use technology.** Participants were universal in their support for devising ways to encourage teacher use of technology aligned with instructional

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goals—whether delivered through preservice education or inservice professional development or both. Noting the continual changes and advances in technology, participants pointed out that the need for training is ongoing and must not only be about how to use technology, but also about how to support student learning.

3. **All students will be technologically literate and responsible cybercitizens.** Today's world is marked by increasingly rapid social, political, and technological change—change that is becoming increasingly more difficult to predict. In this context, participants emphasized the need for educators to re-examine the skills and knowledge assumed to be important in preparing students to become good and productive citizens. In addition to being academically, socially, and emotionally prepared, students will need to be technologically savvy—understanding how to locate information, determine its relevance, determine its accuracy, and integrate it with other sources.

COVER STORY VISION
TIME

4. **Research, development and evaluation will shape the next generation of technology applications for teaching and learning.** As the use of technology in education becomes more commonplace, it becomes critical to understand what we are learning about what works and what does not. Too often individual schools and districts are left without good information that could guide them in making appropriate investments in technology—investments that could result in tremendous changes to the educational experience for both teachers and students. As one participant noted: "There are many examples of successful application of technology in schools. What are some of the major conditions that exemplify successful implementation?" Other research topics suggested by participants included: how technology can address learning problems, the use of technology to facilitate second language learning, the relationship between the features of technology and cognition, technology and performance assessment, equity of access to and use of technology, identification of successful pre-service teacher training models, identification of effective policymaking systems, and promising organizational change strategies.

5. **Education will drive the e-learning economy.** The Internet is fast becoming an engine of innovation in education. As it is revolutionizing business through e-commerce, the Internet is on a course to redefine education. E-learning, or the delivery of education and related services over the Internet, is being touted as the next most innovative application of the Internet, and private investment in education organizations is rapidly expanding.

Participants felt that fostering innovation in education—from the provision of digital learning, digital content, assessment services, tutoring, distance learning, data warehousing, and other forms of instructional technology—was important to encourage. Other areas ripe for innovation included ways of: establishing collaboration among schools, libraries, museums, higher education, and industry; evaluating the quality of educational materials and content; and, archiving public domain historical, cultural, and scientific resources.

CONCLUSION

The Forum on Technology in Education: Envisioning the Future marks the beginning of OET's efforts to review and revise the national educational technology plan. A variety of outreach activities will be conducted over the coming months to solicit additional input from stakeholders on the future use of technology in education. Primary among them will be the solicitation of input into the emerging priorities identified during the Forum via a website constructed for that purpose. In addition, further work will be done to refine and elaborate upon the priorities raised at the Forum. A revision of the plan is expected by fall 2000. Additional information about the development of the revised national educational technology plan—including how you can contribute—can be found at the OET website: http://www.ed.gov/Technology.

APPENDIX A
FORUM AGENDA

FORUM ON TECHNOLOGY IN EDUCATION: ENVISIONING THE FUTURE

AGENDA

DECEMBER 1 AND 2, 1999

GEORGETOWN UNIVERSITY CONFERENCE CENTER
WASHINGTON, DC

A WORKING MEETING sponsored by the U.S. Department of Education, Office of Educational Technology

DAY ONE

8:00-8:30	**Continental Breakfast**
8:30-8:35	**Welcome** *Linda Roberts, Office of Educational Technology, U.S. Department of Education*
8:35-8:50	**Opening Remarks** *Marshall Smith, Acting Deputy Secretary, U.S. Department of Education*
8:50-9:00	**Orientation**
9:00-10:00	**Emerging Technologies: A Map of the Horizon (Presentation by Mary O'Hara Devereaux)**
10:00 -11:00	**Technology in K-12 Education: Envisioning a New Future (Presentation by David Thornburg)**
11:00-11:15	**Break**
11:15-12:15	**Extracurriculars as the Curriculum: A Vision of Education for the 21st Century (Presentation by Roger Schank)**
12:15-1:15	**Lunch**
1:15-3:15	**Technology & Content White Paper Presentations (Part I)**
	Roy Rosenzweig and Randy Bass (Social Studies/History)
	Steven Rakow (Science)
	Andee Rubin (Mathematics)
3:15-3:30	**Break**

FORUM ON TECHNOLOGY IN EDUCATION: ENVISIONING THE FUTURE

AGENDA (CONTINUED)

3:30-5:30	Synthesis of emerging trends, assumptions, and opportunities for leadership
5:30	Wrap-up and orientation to tomorrow's work
	Dinner on own

DAY TWO

8:30-9:00	Continental Breakfast
9:00-9:10	Orientation to Day 2
9:10-10:30	Technology & Content White Paper Presentations (Part II)
	Joan Assey (Arts)
	Linda Labbo (Reading/Language Arts)
10:30-10:45	Break
10:45-12:30	Envisioning the future: Exploring desired future states of education and technology
12:30-1:30	Lunch with U.S. Congressman John B. Larson (D—Connecticut)
1:30-3:00	Synthesis of emerging trends, assumptions, leadership opportunities: Toward draft national goals for technology in education
3:00-3:15	Break
3:15-4:30	Prioritization and refinement of draft goals and strategies
4:30	Wrap-up and Next Steps

APPENDIX B

PARTICIPANTS

FORUM ON TECHNOLOGY IN EDUCATION: ENVISIONING THE FUTURE

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FORUM ON TECHNOLOGY IN EDUCATION: ENVISIONING THE FUTURE

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- Your Comments
- Introduction
- Forum Report
- White Papers
- Forum on Technology in Education
- Emerging Priorities
- '96 ET Plan

White Papers on the Future of Technology in Education

A total of nine white papers have been commissioned to explore a variety of perspectives related to the future of technology in education. Seven of these white papers were presented in December 1999 at the *Forum on Technology in Education: Envisioning the Future* to help inform and guide participant discussions on the visions of the future of technology in education as well as in the major content areas--social studies, science, mathematics, the arts, and reading/language arts.

In addition, two new white papers were commissioned following the Forum on the topics of "e-learning" and technology and disability.

Follow the links below to learn more about these nine white papers and their authors.

Note that these papers are the views of the authors and should not be construed to represent the views of the U.S. Department of Education.

NEW ***E-learning: Education Businesses Transform Schooling*** **by Peter J. Stokes**

NEW ***The Future is in the Margins: The Role of Technology and Disability in Educational Reform*** **by David Rose and Anne Meyer**

Technology in K-12 Education: Envisioning a New Future **by David Thornburg**

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Extracurriculars as the Curriculum: A Vision of Education for the 21st Century by Roger Schank and Kemi Jona

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Rewiring the History and Social Studies Classroom: Needs, Frameworks, Dangers, and Proposals by Randy Bass and Roy Rosenzweig

Forum on Technology in K-12 Education: Envisioning a New Future--Science by Steven Rakow

Technology Meets Math Education: Envisioning a Practical Future by Andee Rubin

The Future of Technology in K-12 Arts Education by Joan Assey

Toward a Vision of the Future Role of Technology in Literacy Education by Linda Labbo

To view a pdf of all the above white papers (515k) click here.

In addition, at the *Forum on Technology in Education: Envisioning the Future* Mary O'Hara Deverauex of the Institute for the Future explored the intersection of technology trends and their implications for society. View her presentation materials here

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Introduction | Forum Report | **Forum White Papers** | Forum on Technology in Education | Emerging Priorities | Comment Here | 1996 National Educational Technology Plan

- Your Comments
- Introduction
- Forum Report
- White Papers
- Forum on Technology in Education
- Emerging Priorities
- '96 ET Plan

E-Learning: Education Businesses Transform Schooling

By Peter Stokes

Commissioned following the *Forum on Technology in Education: Envisioning the Future*, the purpose of this paper is to provide an introduction to "e-learning" and explore the unique role played by the new breed of entrepreneurial Internet businesses making this kind of education possible. In so doing, the paper suggests that the private sector can play an important and valuable role in bringing new levels of innovation, as well as significant capital resources, to the education community.

E-learning is a means of becoming literate, involving new mechanisms for communication: computer networks, multimedia, content portals, search engines, electronic libraries, distance learning, and web-enabled classrooms. It is characterized by speed, technological transformation and mediated human interactions. The success of e-learning programs will depend upon the capacity of schools, parents, children and education businesses to collaborate effectively – simultaneously connecting learners, educators and the community on a global scale, and forcing us to rethink the purpose and architecture of our educational infrastructures in very fundamental ways. E-learning will not replace the classroom, but it has the potential to change the purpose and function of the classroom considerably. E-learning offers us new ways to think about designing and delivering education – not just between the ages of 5 and 18, but across the lifetime.

In addition to examining the opportunities and challenges associated with e-learning, the paper provides examples of new education businesses that are redefining and reshaping the experience of becoming educated. In various ways, these for-profit businesses play a significant role in making e-learning possible for our institutions of learning. All of this suggests that the time to rethink the relation between corporate, government and education institutions is now. In many respects, distinctions between for-profit and non-profit enterprises are fading. Because e-learning represents

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a powerful convergence of technological opportunity and economic necessity, its emergence presents a unique occasion to undertake a considered reevaluation of the role and function of education over the course of the lifetime. Working together, policy leaders, administrators, teachers, students, parents, education entrepreneurs and investors can realize the potential for e-learning to substantially improve and expand the learning opportunities for children in K-12 schools. The work accomplished so far suggests that e-learning can play a substantive role in developing a new breed of literate citizens for the global economy of the twenty-first century.

Click here to view E-Learning: Education Businesses Transform Schooling in pdf format.

To read pdf files, you will need Adobe's Acrobat Reader; if you do not have Acrobat, you can download a free copy from Adobe.

About the Author

Peter J. Stokes
Eduventures.com
Executive Vice President

Mr. Stokes directs research and publishing for Eduventures.com. In 1998, he launched *The Education Economy*, an email publication that has become the most widely read newsletter in the education industry, with a readership extending to more than 70 countries around the world. Mr. Stokes is also editor-in-chief of the monthly print publication *The Education Industry Report* . Prior to joining Eduventures.com, Mr. Stokes was Manager of the Industry Research Group at Daratech, Inc., a high-tech market research firm covering the CAD/CAM industry. Additionally, Mr. Stokes has taught at the postsecondary level, having held positions at Tufts University and the Massachusetts College of Art. He has published and presented papers on distributed learning, has experience in computer-networked classrooms and has taught distance learning courses via the Internet on topics as diverse as writing, literacy and business ethics. Mr. Stokes has a B.A. and a Ph.D. in Literature from the State University of New York at Stony Brook.

E-LEARNING:
EDUCATION BUSINESSES TRANSFORM SCHOOLING

Peter J. Stokes, Ph.D.
EXECUTIVE VICE PRESIDENT, EDUVENTURES.COM

INTRODUCTION

> ***"The purpose of education in this society***
> *is to bring the kids up to be conversant with the most important ideas*
> *and the representation systems that are used to express them."*
> *– Alan Kay, Apple Computer*

Recently, "education" has risen to the top of the charts in public opinion polls. During the late 1990s, growing numbers of state and local election campaigns were waged almost entirely on the back of "education reform." As a result, state and local authorities are now vigorously experimenting with innovative educational programs: vouchers, charter schools, and standardized tests. The fact that so much attention is being paid to matters of educational outcomes, opportunity and equity is – undoubtedly – a good thing. But as growing numbers of people turn their attention to these matters, a seemingly intractable debate ensues over what good education is really about: test scores, "back to basics" or choice.

As a former educator, and as someone who has been both personally and professionally focused on exploring the value and impact of education, I have my own opinions about these matters. And I'm inclined to believe that many of these debates miss the point by a wide mark.

Very broadly, the mission of education is to develop literate citizens. Students need to be schooled not only in alphabetic and numeric literacy, but also to develop a fluent understanding of the history of ideas. More than that, students must strive to become fluent in the ideas of their own time – what in the eighteenth century was referred to as "the spirit of the age." To succeed in becoming fluent in these ideas, learners must – as Apple Computer's Alan Kay suggests – understand and be able to manipulate the systems of representation that bring them to life. And to do that, learners must be social creatures, because learning only takes place when there is an exchange of ideas.

Today when people talk about education, the conversation frequently turns to a new type of education called "e-learning," as well as to the new breed of entrepreneurial Internet businesses making this kind of education possible. Like everything else associated with the Internet, the term e-learning is subject to much mystification and hype. Nevertheless, to talk about e-learning is really still to be talking about literacy, albeit a new kind – a literate understanding of the ideas of a time characterized by new cultural dynamics: globalization, "the new economy," and the web. It is also to talk about a new form of social interaction.

What is e-learning? It is a means of becoming literate, involving new mechanisms for communication: computer networks, multimedia, content portals, search engines, electronic libraries, distance learning, and web-enabled classrooms. E-learning is characterized by speed, technological transformation and mediated human interactions. The success of e-learning programs will depend upon the capacity of schools, parents, children and education businesses to collaborate effectively – simultaneously connecting learners, educators and the community on a global scale, and forcing us to rethink the purpose and architecture of our educational infrastructures in very fundamental ways. E-learning will not replace the classroom, but it has the potential to change the purpose and function of the classroom considerably. E-learning offers us new ways to think about designing and delivering education – not just between the ages of 5 and 18, but across the lifetime.

If there is a mandate to rethink the relationship between education and technology, it is not because technology – by itself – makes people smarter. Anyone who presents such an argument is simply hawking "the new new thing." The real reason to rethink education around the question of technology is that the technology is here – and it is embedded in our lives: in our appliances, our communications systems and our transportation systems. It is not going to go away. As a result, we simply cannot enjoy all of the opportunities afforded us in this new cultural moment unless we are literate in the ideas of our time and the technologies used to express them.

This paper examines the opportunities and challenges associated with e-learning, with particular focus on the new education businesses that are redefining and reshaping the experience of becoming educated. Companies such as Lightspan, eScore.com, Classroom Connect, PowerSchool, and Class.com are mining deep, new veins of educational opportunity. In various ways, these for-profit businesses play a very considerable role in making e-learning possible for our public and private institutions of learning. In some cases, these businesses have begun to compete directly with schools – offering, for example, a complete high school education online. The purpose of this paper is to explore the unique role played by these for-profit businesses in developing and expanding the learning opportunities for children in K-12 schools through the design and delivery of e-learning experiences.

Opportunities and Challenges

Connectivity, content, community. These are the buzzwords of the new education landscape – and it is a global landscape. Today, social, technological, and economic drivers are transforming education systems around the world. As the Internet brings these individuals, cultures and nations together in unprecedented ways, matters of education reform are pushed center-stage. As local economies turn global, the development of a technologically skilled workforce becomes a worldwide concern; and as human capital becomes the chief source of economic value, education and training become lifelong endeavors for the majority of workers. E-learning offers these individuals a potentially less expensive and more convenient way of becoming educated – and of coming into contact with a more diverse group of fellow learners than ever before.

> The capacity for e-learning to make a really significant contribution to education in the U.S. and around the world, however, remains uncertain. There are many challenges to be faced if e-learning programs are to be successful. In the U.S., the vast majority of teachers report feeling under-prepared to use technology in the classroom. While the federal government's e-rate program has done much to wire our nation's public K-12 schools, a great deal of work remains to be done: many classrooms still do not have phone lines and the Internet, therefore, remains largely inaccessible for many students. At the same time, the much talked about pedagogical benefits of rich multimedia educational materials will not be realized until bandwidth issues are

adequately addressed. Because wiring and cabling are expensive both to install and maintain, some schools have chosen to wait until wireless systems become widely available – but this strategy defers the benefits of e-learning and results in some students being disadvantaged. There are also significant costs associated with keeping school computers and network infrastructures up to date – and these products and services will have to become more affordable, perhaps through leasing rather than purchasing options, if schools are going to keep up with and benefit from the most recent technological innovations. Surrounding all these issues is the much broader challenge of providing equitable e-learning opportunities across communities – wealthy and poor alike.

Certainly these challenges will not be overcome without much effort, but there are many reasons for working to overcome them. E-learning represents a long-term opportunity for us to rethink the value of education over the lifetime, as well as its place in our lives. It can also help us to develop the "knowledge workers" required to sustain the growth of the new economy. E-learning is, after all, well positioned to familiarize individuals with the tools of the modern workplace. It also promises to reach and empower greater numbers of learners than brick and mortar institutions have been able to accommodate.

In short, e-learning has the capacity to put more diverse learning resources at the fingertips of students than ever before, while simultaneously connecting them with an increasingly global education community. Moreover, because of the mobility that is characteristic of e-learning, it can become embedded in many daily activities, and this has the potential to reshape our understanding of the time and place for learning in our lives. In the accelerated new economy, knowledge workers are frequently called upon to add to new skillsets. E-learning has the capacity, as Merrill Lynch analyst Michael Moe has said, to replace "just-in-case" learning with "just-in-time" learning.

Of course the success of e-learning initiatives will depend upon the contributions of diverse groups of people: teachers; administrators; families; federal, state and local governments; and the private sector – the education entrepreneurs who are building the new educational infrastructure, designing new educational content and developing new educational tools, as well as the private investors who help make these businesses possible.

THE ROLE OF THE PRIVATE SECTOR

Although we may take public education for granted today, things haven't always been as they are now. And some education reformers warn that things may change yet again. As Andrew Coulson's 1999 book, *Market Education: The Unknown History*, makes clear, our school systems have gone from private to public and – occasionally – back again over many decades. Of course, today, 80% of our K-12 institutions are federally supported public schools – and the dramatic growth in the number of charter schools in recent years suggests that the American people are by and large comfortable with publicly funded education provided it continues to innovate. And there is evidence that, contrary to the views of some proponents of education reform, the federal government is interested in innovation as well. One of the more recent and perhaps most significant attempts at rethinking public education originated, in fact, with the federal government.

A Nation at Risk, a federal report published in 1983, served as an important wake up call to the education establishment. Student performance was seen to be declining vis-à-vis much of the industrialized world, the report warned, and left unchecked this would negatively impact the long-term health of the U.S. economy, as well as individuals' earning power. In response, the private sector began to take an increasingly active role in education debates. Yet the solutions offered by top business leaders – generally in the guise of corporate philanthropy – failed to have a significant impact on student outcomes.

By the early 1990s, however, the pace of change was accelerating. The public began engaging with educational issues with renewed interest. At the same time, technology in the form of word processors and computerized library catalogues became ever more commonplace in our schools and universities. By mid-decade, the Internet had made a significant impact on academic communications – with email taking the education community by storm. A year or two later, the World Wide Web introduced educators and students alike to linked documents hosted on computer servers all around the world. Perhaps most importantly, education entrepreneurs began playing more significant roles in the development and delivery of education and training programs.

Today, the "education industry" – encompassing businesses as diverse as childcare companies, for-profit schools, publishers, school supply companies, corporate training firms, tutoring and test preparation businesses, and, more recently, Internet education businesses – generates nearly $100 billion in revenue annually. The notion that business and education can do important work together is now widely accepted, from Wall Street to Main Street.

Investors are pouring ever larger sums of startup capital into education businesses. Research conducted by Eduventures.com, an education industry market research firm, shows that during the 1990s education businesses received some $6 billion in private equity investments – with $2.6 billion coming during 1999 alone. Internet education businesses are receiving a greater and greater share of the investment pie. In 1997, e-learning companies took 18%, or $81 million, of a total $447 million of private investments. The following year, e-learning's share rose to 25%, taking $198 million of 1998's total $793 million. By 1999, these companies were taking 38%, amounting to $981 million of the $2.6 billion total. During the first five months of 2000, the share for e-learning private investment reached 57%, amounting to $841 million of the $1.5 billion invested.

All major investment firms cover the education industry, from Merrill Lynch to Salomon Smith Barney, from Credit Suisse First Boston to Banc of America. Today investment firms produce two-inch-thick research books on investment opportunities in education, and a number of firms now publish weekly newsletters – all focused on e-learning – to keep investors up to date on opportunities in an accelerating marketplace.

At the same time, investors as diverse as Warburg Pincus, Lazard Freres, GE Equity, Leeds Equity Advisors, Forstmann Little, New Schools Ventures Fund, and others have devoted sizable sums of capital to support the growth of education businesses. Now, a number of the industry's most successful firms – including Knowledge Universe, Sylvan Learning Systems, and Kaplan – have created funds of their own to reinvest in the industry they helped create.

Earlier this year Harvard University launched the David T. Kearns Program on Business, Government and Education to explore ways in which businesses can improve education in the U.S. through cooperation with government and education institutions. Clearly the business of education is on the map, and indications point to enormous opportunities for investors, entrepreneurs and educators in the coming years. Late last year John Chambers, CEO of Cisco

Systems, called Internet education the next "killer app" – one that would make the pervasiveness of email look like "a rounding error."

As an experienced observer of both the for-profit and non-profit activities within the education community, Eduventures.com believes that education entrepreneurs will play a very significant role as agents of change in 21st Century reform efforts. One of the great strengths of entrepreneurship is that it cuts across public, private and non-profit lines. Today, education executives, investors and educators are working side by side to initiate change in entrepreneurial ways. In many respects, education is the last sector of the economy to benefit from the levels of innovation, efficiency and accountability common to the business world. For that reason, education businesses have much to offer the education community – but they also have much to learn from their institutional partners about successfully porting the classroom to the web. In the coming decade, education entrepreneurs – both on the for-profit and non-profit sides – will play a leading role in shaping the future of e-learning markets.

THE E-LEARNING MARKETPLACE

By harnessing the power of e-learning, education businesses have the capacity to transform schooling in many ways. For students and teachers, e-learning offers access to a broad array of content and commentary, interactive self-paced learning tools, a vast community of learners, and distance learning opportunities – very nearly a "classroom without walls." Done well, the net effect of e-learning programs should be a genuine transformation in the way children learn – as well as when they learn and why they learn.

Classroom Learning	**E-Learning**
• Textbooks and reading lists	• Content portals and online resources
• Chalk and talk	• Rich multimedia & interactive content
• Class discussion	• Inter-classroom collaboration online
• Help after class	• Web-based tutoring on demand
• Quarterly report cards	• Real-time student information systems (SIS)
• On school grounds	• Multiple locations

These differences between traditional and online learning should underscore the ways in which e-learning businesses make contact with educators, students and parents on a number of distinct fronts. There are many niches in the e-learning marketplace – and a variety of products and services.

- **Portals** – Web sites that aggregate educational content, lesson plans and other resources online. These sites generally feature powerful search engines for researching on the web, as well as content and other materials provided by partner companies such as publishers, associations and online news sources. Access to content is often made available at no charge to the user. Revenues are typically generated though a blend of advertising, e-commerce and subscription sales. Examples: Lightspan; EdGate.com.

- **Content Providers** – Education sites and software companies which typically focus on branding a curriculum in a specific discipline, such as math or science. These firms, like portals, may derive revenue from advertising and e-commerce, as well as through the sale or licensing of curriculum in the form of printed materials or CD-ROMs. Examples: Classroom Connect; Cogito Learning Media.

- **Community Sites** – Companies which provide schools, classrooms or student clubs with online publishing tools and communication features such as chatrooms, message boards or email. Tools and server space are frequently made available to users at no charge. For revenue generation, these companies rely on advertising and e-commerce. Recent market trends suggest that these businesses will increasingly look to broaden their offerings to include data management tools such as administrative and student information systems. Examples: HighWired.com; FamilyEducation Company.

- **Tutoring** – Frequently these firms have already established brick and mortar tutoring or test preparation businesses. By bringing their services online, these companies make it possible for parents – who typically pay for these services – to participate in and actively support their children's education. Students benefit by being able to access help whenever and wherever it is needed. Revenues are typically derived from fees for services or through subscription sales. Examples: Tutor.com; eScore.com.

- **Student Information Systems** – These companies make it possible for teachers, parents and students to interact with greater frequency and efficiency by making student records – such as grades or attendance data – and class projects available online. Some SIS solutions provide parents with email access to teachers. Revenues are generated through the sale of these systems – whether web-based or software – to schools. Examples: PowerSchool; NCS.

- **Distance Learning** – In the K-12 market, these companies generally take education out of the classroom and into the home – or any number of other locations. (In the higher education marketplace, these firms also market their services for use on campus.) Distance learning firms in the K-12 space target the home-schooling market and also license their services to brick and mortar schools which may not have the resources in-house to deliver certain kinds of content – such as advanced placement courses. Distance learning companies challenge schools to rethink the purpose of the classroom and have the potential to bring quality, interactive education to disabled children who could not otherwise attend school. Revenues are generated through the sale of services to parents or schools. Examples: Class.com; Apex Learning.

Because of rapid technological advances and swiftly evolving market dynamics, these companies may change strategies, revenue models and product offerings quickly and frequently. The e-learning market is also undergoing consolidation – with companies merging or acquiring complementary businesses – and this trend may well accelerate. All this can make it difficult for faculty and administrators to identify for-profit partners who can be counted on to work and grow with them over the long-haul. But this also means that e-learning companies must innovate and build better and easier-to-use products to successfully compete in the marketplace.

SNAPSHOTS OF SELECT E-LEARNING BUSINESSES

The e-learning market is moving rapidly toward consolidation, as portals and community sites partner with or acquire tutoring and SIS businesses, and as content providers and distance learning companies partner or merge to provide a broader array of products and services. What is today a very fragmented marketplace composed of niche players, could in 12 to 24 months be dominated by a handful of large companies providing a full menu of products and services that encompass not only the needs of the K-12 marketplace, but also higher education, corporate training and professional development markets. This means that e-learning markets two years from now may look very different than they do today. As the marketplace consolidates, some of the companies described below may not continue to operate as standalone businesses, but these leading and emerging firms look set to play a significant role in the evolution of e-learning.

- **Lightspan, Inc.**, San Diego, CA (NASDAQ: LSPN) – The portal company provides K-12 and postsecondary educators, parents and students with instructional services that aim to improve student learning by creating links between home and school. Originally a computer hardware and software distributor, the company has shifted its focus to become an online education portal. Lightspan has created a collection of products and services including interactive CD-ROMs, electronic tools, print materials, and Internet services that are designed to increase student interest in learning and parental involvement in education, improve educational equity and increase interaction between parents, teachers, and students. Visit www.lightspan.com.

- **Classroom Connect**, Foster City, CA (Private) – The content provider develops web-based curriculum products and professional development programs for the K-12 market. The company's three principal products – Classroom Today, Connected University and Quest Interactive Expeditions – offer classroom course content, technology training for teachers and "virtual explorations" online respectively. Classroom Connect partners include the American Museum of Natural History, Discovery Channel School, the New York Times Learning Network, and others. Visit www.classroom.com.

- **HighWired.com**, Watertown, MA (Private) – The community site has provided more than 11,000 of the nation's 20,000 high schools with free tools and server space to place their classrooms, school newspapers, sports teams, clubs and guidance programs online. The firm is now looking to extend its relationships with these institutions by providing school-wide web sites that are intended to bring together in more powerful ways the faculty and students already using the company's products on their own. The company recently raised $30 million in private equity financing. Visit www.highwired.com.

- **Tutor.com**, New York, NY (Private) – The tutoring business is one of a new breed of Internet companies variously referred to as "digital marketplaces," "eMarketplaces," or "Internet exchanges." Like eBay, Tutor.com brings together many buyers and sellers and allows them to conduct transactions online. The site aims to provide parents and students with the opportunity to locate tutors, purchase instructional products and services, and get tutoring online via digital white board. Tutor.com also enables individual tutors to market their services to a broad audience. The company's web site features a database of tutors in a wide range of subject areas. Parents or students can query the database by subject, zip code and price. Tutor.com's partners include The Princeton Review, HighWired.com, the NEA, Blackboard and others. Visit www.tutor.com.

- **PowerSchool, Inc.**, Folsom, CA (Private) – The student information systems company provides K-12 schools with web-based solutions that feature real-time information systems, assessment tools and access to online educational resources. The company's products and services are designed to connect students, teachers, administrators and parents more effectively through the web. Teachers can record student grades electronically, and parents can review grades and attendance records on the web. The company recently secured $31 million in private equity financing. Visit www.powerschool.com.

- **Class.com, Inc.**, Lincoln, NE (Private) – The distance learning company offers education over the Internet to students and learners around the world. The company recently launched a program designed to provide a complete high school diploma online. The Class.com program uses a variety of technologies to maximize student learning through the use of video, graphics, sound, and text on the web. Class.com is a for-profit subsidiary of the University of Nebraska. Visit www.class.com.

Collectively, these firms provide K-12 schools with unique competitive advantages – allowing them to provide a potentially richer, more engaging and student-centered education. En route, these e-learning providers help students to develop the skills they'll need to compete in a world that increasingly looks to technology to drive and sustain its economic growth.

CONCLUSION

Despite the opportunity and promise evident in the innovative e-learning ventures currently underway in the K-12 marketplace, it would be a mistake to regard online learning as an educational panacea. By itself, e-learning will not drive up student test scores, nor will it ensure educational equity for all learners. But e-learning businesses and their institutional partners are demonstrating the rich potential of web-based education. The significance and impact of these jointly developed programs is evident in the wide-ranging support they have received from parents, schools, entrepreneurs, investors and policy leaders.

It should also be evident from the brief survey provided here that the private sector can play an important and valuable role in bringing new levels of innovation, as well as significant capital resources, to the education community. One indicator of the power and attractiveness of private sector involvement in the development of e-learning products and services is the number of high-profile non-profit institutions looking to get into the entrepreneurial game. In the postsecondary market, prestigious institutions such as NYU, Columbia, Cornell and others are spinning off their own for-profit subsidiaries. Many other brand name postsecondary schools have partnered with for-profit providers such as Unext.com to distribute their course materials and programs overseas. For many reasons, the postsecondary market can afford to be more experimental than the K-12 market, but the launching of Class.com suggests that the distance separating these two markets may be diminishing. It may not be long before K-12 schools look to harness the resources of the private sector to develop their own for-profit products and services.

All of this suggests that the time to rethink the relation between corporate, government and education institutions is now. In many respects, distinctions between for-profit and non-profit enterprises are fading. Because e-learning represents a powerful convergence of technological opportunity and economic necessity, its emergence presents a unique occasion to undertake a considered reevaluation of the role and function of education over the course of the lifetime. Working together, policy leaders, administrators, teachers, students, parents, education entrepreneurs and investors can realize the potential for e-learning to substantially improve and expand the learning opportunities for children in K-12 schools. The work accomplished so far suggests that e-learning can play a substantive role in developing a new breed of literate citizens for the global economy of the twenty-first century.

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The Future is in the Margins: The Role of Technology and Disability in Educational Reform

By David Rose and Anne Meyer

Commissioned following the *Forum on Technology in Education: Envisioning the Future*, the purpose of this paper is to provide an overview of the role of technology and disability in education reform, with a particular emphasis on the potential impacts of universal design for learning. The authors argue that the benefits to this approach will accrue to all students by forcing a widespread re-examination of the learning goals, teaching methods, and the means of assessment.

When new technologies move beyond their initial stage of development, innovations in curriculum design, teaching strategies, and policies will be driven by the needs of students "at the margin," those for whom present technologies are least effective—most prominently, students with disabilities. For students with disabilities, technology tools can make a dramatic difference, but they are still being used in traditional, "assistive" ways. New technologies have been remarkably effective in this assistive role; even the most disparaging critic of technology in the classroom usually praises the remarkable benefits of assistive technologies for students with disabilities.

While assistive technologies are of tremendous value, they will not provoke fundamental changes in education for most students with disabilities. Next-stage educational technologies will go beyond providing better access to existing methods and materials; they will embody fundamentally different concepts of learning (and thus teaching). While several technologies are serving as catalysts for these new ideas and approaches, the most fundamental change will come in our understanding of goals. Our ultimate educational goals will no longer be about the mastery of content (content will be available everywhere, anytime, electronically) but about the mastery of learning. The implicit goal of education will change from homogenization (all students pointed toward one outcome and measured by one yardstick) to diversification—identifying and fostering the inherent diversity among all of them, identifying new kinds of learning, new kinds of teaching, and new kinds of success. Students with disabilities will have much to gain, and much to offer, in that enterprise.

Click here to view The Future is in the Margins: The Role of Technology and Disability in Educational Reform in pdf format.

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THE FUTURE IS IN THE MARGINS: THE ROLE OF TECHNOLOGY AND DISABILITY IN EDUCATIONAL REFORM

David Rose, Ed.D. and Anne Meyer, Ed.D.

CAST

Introduction

In a remarkable work of social history called *More Work for Mother: The Ironies of Household Technology from the Open Hearth to the Microwave*, Ruth Cowan examines the effects of new technologies in the kitchen. Her main conclusion: new technologies like stoves (which were invented in the 18th century and replaced traditional cooking on the open hearth) did not generally make less work for mother. But stoves did transform our culture's concept of what constituted a meal, what was meant by cooking, and even who and what a kitchen was for. Most important, the new technologies of the kitchen democratized cuisine—bringing meals that were more nutritious, more differentiated (multiple dishes, multiple courses), and more attractive to a wide range of households where such meals had been previously unavailable.

In our view, the effects of new technologies in education will be similar. These new technologies will not make less work for teachers. But they will transform the work—making it more nutritious (in Piaget's sense of aliments for learning), more differentiated, more engaging, and more democratized. Perhaps most important, these new tools will change our very concept of learning, and thus of teaching.

When new technologies move beyond their initial stage of development, innovations in curriculum design, teaching strategies, and policies will be driven by the needs of students "at the margin," those for whom present technologies are least effective—most prominently, students with disabilities. The beneficiaries of these innovations will be ALL students.

The present: Assistive technologies

Most educational technologies in classrooms are at the early stages of adoption. Like most new technologies in the early stages, these educational technologies are presently being used in "traditional' ways, they are new tools being used to do "old" things. Word processors, calculators, and electronic learning games are good examples—these tools provide improvements in efficiency over print-based technologies (e.g. pencils and paper) but they do not fundamentally change the nature of the educational enterprise.

For students with disabilities, technology tools can make a dramatic difference, but they are still being used in traditional, "assistive" ways. These tools primarily provide access to traditional activities that are otherwise inaccessible. New technologies have been remarkably effective in this assistive role; even the most disparaging critic of technology in the classroom usually praises the remarkable benefits of assistive technologies for students with disabilities.

Examples providing evidence of the power of technology for individuals with disabilities are not difficult to find. For individuals with motor disabilities (who may not have the fine motor control required to manipulate a pencil, keyboard. or mouse), the advantages of expanded keyboards, single switch devices, head-mounted infra-red pointers, speech recognition software and word prediction are obvious. Similarly, refreshable Braille devices, talking word processors, screen readers, screen enlargers, and tactile graphic pads offer clear advantages individuals who are blind.

It is not hard to envision the power of new access technologies currently being developed in laboratories all over the world: implanted sensory chips (such as cochlear implants) for both hearing and seeing, neural control devices for robotic arms and legs, convertible wheelchairs that adapt to both sitting and standing positions, and cognitive prostheses for memory deficits.

The Future: Universal Design for Learning

While assistive technologies are of tremendous value, they will not provoke fundamental changes in education for most students with disabilities. Next-stage educational technologies will go beyond providing better access to existing methods and materials; they will embody fundamentally different concepts of learning (and thus teaching). They will change the learning goals, the teaching methods, and the means of assessment for all students. Several technologies are serving as catalysts for these new ideas and approaches.

NEW TECHNOLOGIES THAT ARE CHANGING OUR CONCEPT OF THE NATURE OF LEARNING

New computer-driven technologies (e.g. PET scans, fMRI, qEEG) are revolutionizing the way in which we are able to study learning as it happens in the brain. These new technologies reveal, in ways that were unimaginable ten years ago, that learning is (1) modular, (2) distributed, (3) parallel, and (4) heterarchical. While a full explication of these observations for understanding the processes of learning is beyond the scope of this paper (see Meyer and Rose, in press) several aspects of the research can be highlighted.

These new tools and methodologies allow us to "see" the brain as it learns—by performing enormously complicated computations on subtle changes in brain activity that are then displayed as a simple "topographical" map of activity on a computer screen. The dominant impression from these computed images is how "modularized" the brain seems to be. It is immediately apparent that the brain learns, for example, about the color of an object in a different region than it learns about the shape of the same object. Moreover, it processes the word "cat" in a different region when it is presented in print than when it is presented in speech, and it uses an entirely different area to compose the word "cat" for speaking. The brain has a large number of such distributed modules that work "in parallel," each highly specialized for learning about specific aspects of the world.

The pattern of activity across different modules clearly depends on the task—different modules are active when one listens to a speech or when one listens to a symphony, for example. In a general sense there is a "signature" of activity in the brain that corresponds to the kind of task being performed. But the distribution of activity for any task also varies across individuals. Each individual reveals a particular "map" of activity—differing both in the proportions of space devoted to each of the modules, and in the composition of different modules used to accomplish the same task. The brain of an individual with perfect pitch, for example, shows a strikingly different distribution of activity from that of an individual with "normal" pitch perception, or one who is "tone deaf."

Significantly, the "map" of activity changes as the brain learns. Recent research has shown that a novice uses very different modules in the brain for the same task than does an expert. New technologies allow us to watch the brain over the course of learning, as it changes from using one set of modules to another. Surprisingly, these new techniques have also shown that the size of an individual processing module can grow (and others can shrink) with experience, even in adults.

New technologies for studying the brain are yielding an increasingly more accurate articulation of the concept of learning—revealing not one generalized learning capacity, but many different "modules" and "distributed processes" for learning within the same brain. Further, it is becoming clear that individual brains differ from each other not in a general ability (like IQ) but in many different kinds of specific abilities.

New technologies that are changing our concept of media

The new media, especially digital media, differ from traditional media in a number of ways. In our view, what is of most significance to the future of education, especially for students with disabilities, is the unequaled flexibility and transformability of digital media.

Print-based media provided some clear advantages over earlier forms of communication such as oratory. Print enabled permanent recording, was portable, and was, at least by the 20th century, relatively inexpensive. In time, and with these advantages, printed text came to dominate learned discourse, and education became dominated by book learning.

The new media (digital text, digital images, digital audio, digital video, digital multimedia, and networked environments) provide many of the advantages of print-based media but they also bring new advantages. Notable is the malleability of the new media. While they, like print, can provide a permanent representation, they do not have the same "fixed" quality as print. Instead, they remain malleable, transformable from one thing to another, more like raw clay than fired pottery.

The consequence is enormous flexibility and the capacity for transformation from one medium to another (e.g. text-to-speech, speech-to-text, text to touch (e.g.Braille), image to touch (haptic images, tactile graphics) and others). In addition, the new media allow multiple representations of meaning that may be used redundantly for clarity, complementarily for enhanced meaning, or even discordantly for multiple meanings (e.g., using text on video (captions), video on text, multiple sound and visual tracks, graphics on video (e.g. signed captioning), sound maps, visual light organs, and others).

The capacity to use multiple media in these and many other ways leads to a more diversified, flexible palette for communication—a palette that takes advantage of the varied strengths and weaknesses of each medium. While the hegemony of printed text has already disappeared in such high-impact fields as advertising, entertainment, and communication in the culture at large, the legacy of print continues in schools. In the years ahead it is clear that text, still dominant in education, will give way to a more intentional use of varied media for instruction.

Instructional designers in the future will tailor their use of media to the task, to different kinds of learning, and different kinds of students. They will use the transformability and flexibility of digital media to reduce the barriers and inefficiencies inherent in fixed, one-size-fits all, printed textbooks. Moreover, they will develop expertise in the representational and expressive qualities of each medium, and the new blends that will develop, so that they can reach a broader set of students, with a broader range of knowledge.

Students with disabilities, for whom the transformations and multiple representations will vastly increase access and learning opportunities, (e.g. talking books, descriptive video, ASL tracks) are the first beneficiaries of the new media. The incidental beneficiaries will include the teachers of subject matters like math, music, geography, physics, and other subjects that have never easily yielded their magic through linear text. But the ultimate beneficiaries will be all learners, each of whom has experienced in one way or another the barriers to motivation and comprehension that an over-reliance on text and other fixed media have wrought.

NEW TECHNOLOGIES THAT ARE CHANGING OUR CONCEPT OF THE LEARNER

The same digital technologies that allow us to examine the biology of learning and to discover and apply the power of new media also allow us to recognize the profound and differentiated (rather than general) ways in which individual learners differ from each other. Continuing the pioneering work of Gardner, Sternberg, and others, this avenue of research continues to show that there is not one "typical" learner with a limited number of variants but instead a great variety of learners—as many as the interactions among modules and architectures in our brains.

In addition, the more differentiated use of media for instruction reveals that individuals who are defined as "learning disabled" within print-based learning environments are not the same individuals who are defined as "learning disabled" within video- or audio-based learning environments. Such revelations splinter the old categorical divisions between "disability" and "ability" and create new descriptors that explicitly recognize the interaction between student and environment in the definition of strengths.

As a result, educators take more notice of the "unusual" strengths of individuals with disabilities – e.g. the prodigious feats of visual memory in the autistic child, or the extraordinary capacity to recognize facial expression in aphasics. In the same context, myriad differences emerge between learners formerly classified in the category of "normal" learners. Against this backdrop, individuals with disabilities fall along a spectrum of difference and the convention of the "regular" student disappears as a normative model.

New technologies that are changing our concept of teaching and learning

The flexibility, malleability, and interactivity that characterize new media provide the basis for educational designs that are impossible with traditional fixed methods and materials, designs that emerge as necessary in light of changing concepts of learning and individual differences.

These new designs reflect a more articulated understanding of learning and avoid "presentational" environments (like books and lectures) in favor of truly instructional environments where students are consistently supported in learning how to learn. Individualizable challenge and support are built into every element of the curriculum, every learning experience. Skill-development materials, for example, can be designed to provide built-in models of performance, opportunities for supported practice, immediate feedback, and extended "communities of practice." In that respect, these new environments more closely resemble traditional models of apprentice learning than "book-learning."

Congruent with apprentice models, these new designs exploit the power of new media to individualize and customize, making it possible and imperative to meet the enormous challenge of individual differences (including those who are defined as having disabilities). To do this, they do not provide one-size-fits-all presentations but highly malleable environments that provide the right level of support and challenge for every individual student.

In accordance with the findings on individual differences from the neuroscience's, new learning environments provide the right level of support and challenge in three ways.

First, they provide multiple means of representation. This means that instructional designs assume that there is little value in a single canonical representation of the information in any particular task or problem. Instead, new designers will assume that to provide basic access for some students (e.g. for students who are deficient in one modality or other, like a student who is blind), and multiple routes to meaning for all students (e.g. representing a math concept both in text and graphically) it will be both necessary and preferable to provide multiple representations of meaning.

Second, they will provide for multiple means of expression. This means that instructional designers will decrease their insistence on a single mode of communication from the student as the basis for expression or evaluation. It will be routine to assume that while many students will write (or type) their essays, there will also be alternatives that involve rich mixes of writing, illustrating, speaking, video-making, and drawing. The method of evaluation will suit the task and the means. Students will be required to meet a higher standard of expressive literacy—knowing in what contexts (for which purposes and for which audiences) to use text, images, sound, video, or combinations of media. Evaluation will be sensitive to purpose, audience, and the strengths of the learner. The creative expression of students with motor difficulties will not be evaluated via handwritten assignments.

Third, the new designs will provide multiple means of engagement. Most students are often unengaged or bored in school. There is no single solution to this problem because of the range of individual differences—there are many different reasons for their lack of engagement, not one. Students with disabilities, as usual, highlight the issues. The same design which would likely engage a student with ADHD (a high degree of novelty and surprise, for example) would be absolutely terrifying (and thus disengaging) to a student with Asberger's Syndrome or autism. New designs will be cognizant of the centrality of motivation in learning, and of the individual differences that underlie motivation and engagement. As a result, and given the flexibility of new media, they will provide alternative means of engagement—more novelty and surprise in the learning environment for some students, less for others, for example.

These flexible designs are called *Universal Designs for Learning*, and while initiated to meet the needs of students with disabilities and those with special talents, they are ultimately more effective with all kinds of learners.

NEW TECHNOLOGIES THAT ARE CHANGING OUR CONCEPT OF ASSESSMENT

In traditional assessment, the *outcomes* of learning are measured—the number of science facts recalled, the percentage of words spelled correctly. The interactive capacity of new technologies allows us to create dynamic assessments that measure not just the outcomes but the processes of learning. In so doing we will be able to understand what kinds of strategies a student is following, what kinds of strategies or approaches are lacking, what aspects of the task environment bias the student toward successful or unsuccessful approaches, and what kinds of additional strategies might best match their learning style.

Most important, the new technologies allow two-way interactive assessments. With these technologies we will be able to create learning environments that not only teach but also learn. By distributing the intelligence better between student and environment, the curriculum is able to learn about the student (their individual strengths and styles) and keep track of the successes and failures of its own methods. The result is a curriculum that becomes smarter, not more outdated, over time.

Finally, dynamic assessments will be universally designed. By providing a full range of customizations and adaptations as a part of assessments, we will be able to accurately evaluate student performance and the processes that underlie that performance. The accuracy will come from the capacity to evaluate performance under varying conditions—ranging from conditions where the student's performance is constrained by barriers inherent in specific modes of representation, expression, or engagement, to conditions where appropriate adaptations and supports are available to overcome those barriers.

Conclusions

The result of new technologies will be a re-centering of the core agenda of schools on learning instead of content. This will be fostered by advances in our understanding of what learning really is, how diversified it is, and which methods—such as Universal Design for Learning—are articulated and flexible enough to meet the diverse learning needs of all the students.

But the most fundamental change will come in our understanding of goals. The ultimate educational goals will no longer be about the mastery of content (content will be available everywhere, anytime, electronically) but about the mastery of learning. At commencement, we will graduate students who are "expert learners." They will know their own strengths and weaknesses, know the kinds of media, adaptations, strategies, and external technologies they can use to overcome their weaknesses and extend their strengths, and the kinds of colleagues who are likely to complement their own patterns of learning and performance. They will be prepared for a changing world, not a static one, prepared for the world in which they will actually live.

The particular benefit for students with disabilities is that the new technologies will, by necessity, recognize both the reality and the virtue of diversity. The technologies of the future will be more, not less, diverse, and they will engage many kinds of learners. The implicit goal of education will change from homogenization (all students pointed toward one outcome and measured by one yardstick) to diversification—identifying and fostering the inherent diversity among all of them, identifying new kinds of learning, new kinds of teaching, and new kinds of success.

Students with disabilities will have much to gain, and much to offer, in that enterprise.

DEPARTMENT OF EDUCATION

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Technology in K-12 Education: Envisioning a New Future

By David Thornburg

"*We must prepare learners for their future, not for our past.*"

Technology must be thought of in terms of the deep systemic changes needed for K-12 education to meet the needs of the coming years. This observation leads to two important ideas:

1. How we use technology in education is more important than if we use it at all.
2. Unless our thinking about education is transformed along with our continuing expansion of telematic technology into the classrooms, our technology investment will fail to live up to its potential. Several goals are proposed in light of this perspective:

    - Staff development should be moved to the number-one position in any dialog on technology in education, and it needs to focus on the effective use of technology in support of pedagogical and curricular issues appropriate to a redefined concept of schooling needs to be completely overhauled around the new skills that educators will need to operate in an educational setting appropriate to the next century.
    - Every educator and learner must acquire three new foundational skills:

1. Know how to find information.

2. Know to determine if what is found is relevant to the task.

3. Know to determine if the relevant information is accurate.

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- Every learner needs universal access to telematic learning tools.
- We need to continue and expand projects that bring rich educational materials in the public domain to all.

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TECHNOLOGY IN K-12 EDUCATION: ENVISIONING A NEW FUTURE

David D. Thornburg
Director, Thornburg Center

How Do We Envision The Future Of Technology In K-12 Education?

- **What should the future role of technology in education be?**

In his book, *Electric Language: Understanding the Message*, Canadian media theorist, Eric McLuhan said:

> "Animals evolve by incorporating into their bodies new technology, whether by growing longer teeth or by modifying their digestive systems. Human evolution works in the opposite manner. With the first inventions, human evolution suddenly shifted from the realm of biology to that of technology. Animals incorporated; we discorporated. We extended into the environment various parts of the body, various limbs and organs and, with electricity, the central nervous system. Most recently, computer technology and its children now extend around the globe the hemispheres and other elements and organs of the brain. It remains only to extend the mind itself."

Our topic is the role of technology in education, more specifically computer and communication technologies which have combined to create the telematic revolution bursting into virtually every aspect of our homes, workplaces, and schools. By thinking of technologies in the broader sense as extensions of mankind, we give ourselves the capacity to see both the power and the opportunity these new tools afford. Their power comes not just from the fact that technologies allow us to do old jobs in new ways, but that they can be used to help us do things in education that were heretofore impossible. We have the opportunity to use technologies in ways that support modern pedagogical thought devoted to the premise that all are capable of learning, even if the pathways for each learner are different.

This observation leads to two important ideas:

1. How you use technology in education is more important than if you use it at all.
2. Unless our thinking about education is transformed along with our continuing expansion of telematic technology into the classrooms, our technology investment will fail to live up to its potential.

Learning does not take place better or faster simply by replacing one instructional medium with another. The effective use of technology in education requires thought, experimentation, and a willingness to spend the time needed to develop and refine strategies until they are proven to be effective. Patience is important; it takes time to see the results of our efforts.

The topic of educational technology is especially important today. Throughout history education has been impacted by three major inventions:

1. the phonetic alphabet

2. printing

3. telematics (computers connected to networks)

While we have had computers in classrooms for many years now, they have yet to be used in ways that assist in radically transforming the very structure of education. But, just as education was transformed by the invention of writing, and again by the invention of the printing press, it will be transformed by the telematic revolution as well. What better time can we imagine to launch this third transformation than the start of a new millennium?

Education serves many purposes in our society and these purposes have changed over the years as we have grown from a cluster of colonies to assume the leadership role in the global economy. Throughout time, the core purpose of education was to insure that our citizens had the skills they needed to actively participate in a democratic society. As Thomas Jefferson said: "I look to the diffusion of light and education as the resource most to be relied on for ameliorating the condition, promoting the virtue, and advancing the happiness of man."

As we complete the twentieth century and prepare for the twenty-first, it is important to realize that our world is far different from the one which existed a hundred years ago. In the 19th century, a largely agrarian workforce existed alongside an emergent industrial economy powered by muscle, water and steam. Since the turn of this century, we have had the flight of airplanes, commercial radio broadcasts, television, the invention of modern computer technologies, the emergence of new sciences (e.g., bioinformatics, chaos and complexity) and a continued rapid increase in the development of new information in a myriad of fields and endeavors.

But while it can be argued that information has been growing at exponential rates since the Middle Ages, the key element of the past fifty years has been the exponential growth of our *access* to this information. The product of information times access has been driven by confluence of modern computer and communication technologies. Information, once scarce, is now abundant. Furthermore, the widespread availability of information has led to the rapid discovery of new information that, in many cases, transforms the value of the things we already know, forcing us to become lifelong learners. The half-life of information seems to be shrinking. While some of the things we learn last forever (literacy, numeracy), other topic s change so rapidly that much of what we are taught in school is rendered obsolete by the time we enter the workforce. This is especially true in the sciences and engineering.

An extreme example of the short shelf-life of information can be found in the training requirements for those who will live aboard the International Space Station. The scheduled on-orbit time for a crew on the ISS is 156 days. Several factors contribute to this duration, one of which is that, after this time, the crew no longer has the relevant information needed to continue the mission. And this takes into consideration the just-in-time training which is provided once the crew is on-orbit. The emergence of a continuous learning model contrasts sharply with the traditional notion that school (learning) is followed by work, which is then followed by retirement. The rapid changes of our era have insured that work and learning will be closely aligned with each other throughout our lives.

In the world of the past where access was limited, information was treated as a scarce resource, and educators had the task of imparting this information for the benefit of learners. We used to live in a world where content was king. That world no longer exists. Content is abundant, and is, therefore, a poor basis on which to base an educational system. What is scarce today is context and meaning. It used to be the mark of an educated person to have a vast reservoir of facts on which to rely. Today this skill is of much less value. The educational system of today needs to impart to all learners three new foundational skills:

1. How to find information.

2. How to determine if what is found is relevant to the task at hand.

3. How to determine if the relevant information is accurate.

These skills were of seemingly less importance in an educational system driven by textbooks. Students would assume (sometimes wrongly) that what was in the textbook was relevant and accurate. This assumption was aided by the fact that students were tested on the material in their textbooks, lending further authority to these sources of information. As for finding information on one's own, this skill was generally not developed in depth unless the learner went to college or graduate school. An unfortunate byproduct of textbook-based education is the tendency of people to accept as true virtually anything they see in print. Since we were taught to accept what was in textbooks as true, even when it wasn't, the transference of implied veracity to other printed documents was a logical byproduct.

Fortunately, if we accept the three skills above as part of the "new basics," we will be providing all learners with valuable skills that will last a lifetime.

Global awareness is also required to participate in the world of the future. As electronic commerce grows in popularity, all ventures have the opportunity to become global in scope. Web sites for companies in the United States can be accessed virtually anywhere in the world, bringing new opportunities to ventures of all sizes. However, in order for these new markets to be reached, it is essential that those working for these companies have the requisite skills to understand the language, culture and history of the countries with whom they are doing business. The Internet brings the entire planet into our grasp, making the understanding of other cultures critically important.

➢ What will the future of education look like?

As with schools in the 19th century, those of the 20th century were structured around the idea that time would be constant and learning would be variable. Students were presented with subject matter over a fixed period of 180 days, and then were tested on their ability to master the content in that period of time. While some have argued that 180 days is no longer enough, their calls for a longer school year miss the point. Any fixed period of time will still produce variable results. Some can master certain content quickly, and others need more time. Simply replacing one fixed-time model of education with another is a mistake. After all, if it isn't necessary for everyone to master a particular subject, then why is it taught? And, if it *is* important, why don't we give learners the time they need to gain mastery? When I fly in a commercial airplane I don't care if my pilot spent six months or six years learning to master flying — all I care is that she achieved excellence before I came aboard.

A system based on fixed time and variable learning is not an educational institution, it is a filtering institution: it separates those who learn quickly from those who do not. Rather than address the needs of each learner, we label some children as "slow learners," and relegate them to the scrap heap of society. While it might be argued that, in the past, those who lacked the capacity to fit into the mold of schooling could still find gainful employment, those days are fast diminishing. Lifelong learning is the norm, and jobs that can be done by those with little education are either being automated out of existence or are being exported to other countries where low-wage jobs still support a viable lifestyle. Meanwhile, jobs requiring high levels of skill are going begging. The average salary of jobs in the information technology sector is $53,000 (compared with an average US salary of $30,000), and yet close to 400,000 of these jobs are vacant because we lack a sufficient number of qualified workers to fill them.

The concept of schools as filters is a product of the Industrial Age, and it has no place in the society of the next century. Twenty-first century schools will provide whatever support is needed to help learners achieve excellence. The idea of school as a fixed-time activity will be replaced by the concept of continuous learning built around a variety of tools and techniques.

In addition to learners being in the physical company of each other with a caring teacher as a guide and instructor, "schools" will reach out to wherever learners are through whatever media make sense at the time — television, radio, e-mail, the web — all these and more can be harnessed in support of an educational system built around the idea that learning should be a constant and time should be a variable. Learners who want to do research in a library at 2:00 AM will be able to access electronic documents from home through the web. Those who want to hear an expert's perspective from another country will be able to take part in a videoconference from their bedrooms or dens. This represents a fundamental shift in thinking from school as a place to school as an activity.

This move from noun (place) to verb (activity) is an essential point to grasp in the redefinition of schooling. It not only conveys the idea that "school" can be in session from a variety of locations and times, but that learning is a process we engage in on a regular basis throughout our lives. Longshoreman and philosopher Eric Hoffer once said:

> "In a time of drastic change it is the learners who inherit the future. The learned usually find themselves equipped to live in a world that no longer exists."

We have clearly entered a world of drastic change, and the shift of school from place to activity is a necessary transformation if our educational institutions are to be relevant in the lives of learners.

Inexpensive compact technologies will have an important role to play in defining schooling. The rapid development of battery-operated computers with wireless access to the web provides just one hint of what lies on the horizon. Devices that today occupy an entire backpack will soon be redesigned to fit comfortably in the palm of the hand, and be priced in the same range as today's portable radios. And, while networked technologies will dominate the future, standalone technologies used for the creation of physical documents will still have their place. The challenge presented by these new tools is not technological, it is philosophical. There are many twentieth century educators who will resist the shift to the new paradigm. They will need a tremendous amount of staff development to transform their models of teaching to fit the needs of education in the coming years.

The 21st century classroom will be wherever the learner is located — a room at a school, on the bus ride home, in the park, at a museum, or on the playground. Traditional tools (e.g., books, pens and paper,) will co-exist with the high-tech tools of the telematic era that is still in its infancy. The teacher's role in this distributed setting will be quite different from that of content presenter and test giver. A more productive role will be that of co-learner — an expert guide who helps students navigate the subjects being explored, but who is open to new discoveries and pathways along the journey.

The teacher in this setting will operate in a system based on four components: campfires, watering holes, caves, and life. The campfire is the informational space associated with lectures and other methods of direct instruction. The watering hole is the conversational space occupied when learners converse among themselves or with their teachers about a particular topic. The cave is the conceptual space where ideas are developed in relative solitude and where student projects are designed and built. Life is the contextual space where the things that have been learned are applied in the world outside of school. Learning has always taken place in these four spaces, yet twentieth century schools often failed to provide the right balance, and learning suffered as a result.

Traditional schools are designed to facilitate "campfires," lectures given by the teacher. We have learned to use these facilities for moderated conversations (watering holes), but they are ill-suited for reflection and the extended construction of student projects (caves). Their isolation from the world outside the classroom makes context (life) difficult to achieve as well. We can imagine schools looking very different if they had been designed from the beginning as places built around dialog or reflection or contextual application in the real world. The nice thing about telematic technologies is that, unlike physical buildings, they can be applied in all four of these learning spaces with equal ease.

Once these four learning spaces are understood, they provide a framework around which teachers, students, family members and the community at large can envision educational opportunities. The roles of these constituencies in support of learning will vary from community to community, and will change over time within a single community. Flexibility is the key concept for the effective definition of the roles played by different members of the learning community.

- **What impact will technology have on teaching and learning in the near-term? In the long-term?**

In a 1994 speech (and in others since then), Vice President Gore said:

> "I've often spoken about my vision of a schoolchild in my home town of Carthage, Tennessee being able to come home, turn on her computer and plug into the Library of Congress."

There are several relevant observations to be made about this quote that relate to the effective use of technology in improving educational outcomes for learners. First, the Vice President refers to the educational activity (perusing the Library of Congress), not to the technology itself. This is an important point. In our rush to bring technology into schools, some have missed the point and talk about student/computer ratios rather than how the technology is being used to accomplish solid educational goals in unique ways. Technology is not the point — learning is. Any educator should be able to explain the curricular and pedagogical objectives of any tool in the classroom, whether it is a book, the blackboard, or a computer connected to the Internet.

Another point made in the quote has to do with access — both to the Library of Congress (whose physical collection is closed to young people) and to rural America (Carthage has a population of about 2,000). One of the great promises of educational technology is that it makes available to all what was once only available to a few. Rare documents that researchers had to schedule appointments to examine have now been digitized and posted on the web for anyone to access at any time. Initiatives like the e-rate are helping to bring affordable broadband connections to schools throughout the country. Rich content and universal access are two important themes when talking about the effective use of technology in education.

Modern technologies are space collapsers, time shifters, and creative tools that extend our reach.

In the pre-wired world, educational resources were largely confined to the community in which the school was located. The Internet eliminates geography as limiting factor. Information can be gleaned from libraries, museums, research centers, and educational institutions all over the world. A child in a remote hamlet can have access to the same reference materials as one located in the most cosmopolitan city. Geography no longer determines whether students will have access to up-to-date information, or if they will have access to topics that are interesting to explore, but might only appeal to a small number of enthusiasts.

Just as geography is transcended by telematic tools, so is time. The Library of Congress and other powerful educational web sites can be explored any time of the day or night, every day of the year. A learner wanting to check out the works of Nathaniel Hawthorne can download his works for free from Project Gutenberg long after the local library has closed for the night.

As our modern learning technologies become more reliable and ubiquitous, they will have an increasingly positive impact on student creativity. The world of book-based learning and ten-page written reports is now augmented by the capacity of students to create multimedia simulations of a topic being studied, rather than being constrained to express mastery solely through the medium of a written report. Access to multiple expressive modalities is important. As Howard Gardner's theory of multiple intelligences has shown, each of us has multiple pathways to learning, only a few of which were valued in the schools of our youth. Today's technologies expand the modes through which students can develop and express their mastery of a subject.

Beyond expanding the breadth and depth of educational resources available to teachers and students, resources such as the Library of Congress' American Memory Project can help stimulate a deeper interest in a subject. Consider, for example, the difference between reading a textbook description of Bell's invention of the telephone, and reading the handwritten letters Bell sent to his fiancé and others as his work was proceeding. His papers, carefully digitized and available through the American Memory Project, reveal the warm human side of this great inventor that is likely to be omitted in a textbook description of his work.

Resources like this not only help learners gain mastery of subject, but also help them develop a deeper relationship with the topic being studied. By placing a human face on academic topics, web-based access to primary source materials can make learning come alive for many students.

Educators are also great beneficiaries of the telematic revolution. In addition to providing access to reference materials on virtually any academic subject, on-line communication tools can help educators collaborate and converse with peers all over the world. Much of the technology needed to do this is in place today — and it will become even more powerful and commonplace in the future. An educator looking for tips on the best way to approach a new topic with students can search for information on the web, take part in a synchronous chat, or post a query to a listserv and wait for a response. The development of inexpensive desktop videoconferencing equipment opens up new opportunities for casual dialogs on a wide range of topics, and helps overcome the sense of isolation sometimes felt by educators whose areas of interest have few local enthusiasts.

In addition to conversing with peers, communication with learners, their parents, and the community at large is facilitated with the same tools. Parents who, for whatever reason, can not attend a student study team meeting at school can take part in this meeting through videoconferencing. This assumes, of course, that the requisite technology is available to parents at home or at some other convenient location. Fortunately, the rapid decline in computer prices is increasing the penetration of Internet-ready computers in homes at almost all income levels.

This view of technology use in education is highly positive, but there are pitfalls as well. One of the most important caveats is to avoid falling through the looking glass. Virtual worlds have their place, but these tools need to be used in service of the physical world in which we all live, work, play and learn.

Just because an educational task can be conducted using technology does not mean it should be. There are many aspects of education for which computers are very poor substitutes for existing methods. No videoconference will be as good as a face-to-face meeting. No portable display device on the market today is as cheap or has the image quality of a printed page. It is a mistake to think that new media displace old ones. People didn't stop painting pictures once the photographic camera was invented. Nothing of value is gained by moving drill and practice from a cheap workbook to an expensive computer screen.

On the other hand, no book can contain an interactive multimedia program, and no pencil can be used to build a student's simulation of an ecosystem. The key idea to keep in mind is that the true power of educational technology comes not from replicating things that can be done in other ways, but when it is used to do things that couldn't be done without it. Word processors are wonderful tools, but they are simply an extension of the typewriter. Multimedia authoring tools, on the other hand, allow the creation of expressive media that was impossible to achieve before computers came to our classrooms. This doesn't mean we should stop using word processors, only that we need to be on the constant lookout for the new things technologies let us do in education — things that were inconceivable in the pre-wired classroom.

How Can We Best Realize This Vision for the Future of Education?

- **What should our goals for the use of technology in education be?**

The current national plan is based on four pillars:

1. Modern computers and learning devices will be accessible to every student.
2. Classrooms will be connected to one another and to the outside world.
3. Educational software will be an integral part of the curriculum.
4. Teachers will be ready to use and teach with technology.

In the years since this plan was created we have made a lot of progress toward these goals, although we have fallen short on widespread achievement. Even though we did not achieve the goals, it is important that we had them because they helped focus our national diabg on the effective use of technology in education. Should we have these goals? Yes. Could we have attained them? Yes. The fact that we fell short says more about the challenges of transforming education than it does about the quality of our objectives.

Now it is time to create a new plan — one for the next five years — a plan that bridges the end of a millennium and the start of a new one. At first blush it would seem appropriate to maintain the same objectives since we still have a lot of progress to make before these goals are achieved. And yet, admirable as these goals are, they are not enough. As this document has tried to show, we need to think of technology in the broader context of redefining public education for the United States. The four pillars of the current plan make no assumptions about changing the structure of education. They leave unasked the questions relating to the relevancy of our current model for schooling. They address only the tools, not the structure of the system.

The new educational technology plan needs to take a broader perspective. If the structure of schooling is antithetical to the learning needs of the coming years, using new tools will do nothing to help the situation.

Marshall McLuhan once said:

> "We look at the present through a rearview mirror. We march backwards into the future."

What he meant by this is that we view all new artifacts through metaphors based on the ones that preceded them. The first automobile was called a "horseless carriage," for example. While this name helped identify the new device, it also hid the fact that there was something far deeper than a horseless carriage hidden in the concept of a motorized vehicle. The modern automobile is a far cry from the old horseless carriage.

We are confronting the same challenge today as we look at the telematic technologies of education. We talk about the web as a library, a museum, a radio or television, and so on. These are just so many "horseless carriages" that obscure the fact that, whatever the web means for education, it means far more than any one metaphor can describe. Just as horseless carriages were limited by the horse paths they took, educational technologies are limited by the prevailing structure of schooling. The fact that we can look at an engraving of a classroom from the Middle Ages and recognize it as a classroom should shock us. Our current technology plan talks about incorporating telematics into existing schools, with existing schedules, and existing curricula. This tidily avoids having to deal with the deeper issue: Today's schools are based on outmoded paradigms of learning. The crafting of new educational technology goals should take this into account.

First, I would propose that staff development be moved to the number-one position in any dialog on technology in education. Unless effective staff development is in place, the only thing that will change when schools incorporate technology is their electric bill. The staff development should be based not just on knowing how to operate computers — most educators today have computers of their own at home. The staff development needs to focus on the effective use of technology in support of pedagogical and curricular issues appropriate to a redefined concept of schooling.

Another important aspect of staff development is technological fluency. Educators need to know how to use telematic tools for learning so well that they are as natural as books and pencils. One reason this is important is because, even though many students learned how to use computers at home, they generally have not learned how to use them as tools for learning. This requires the guidance of educators or others skilled in this task. Unless all educators have mastered these tools for their own learning, they will be hard-pressed to develop these skills in their students.

Second, preservice education needs to be completely overhauled around the new skills that educators will need to operate in an educational setting appropriate to the next century. According to a Department of Education report, *The Baby Boom Echo: No End in Sight*, teacher retirement and increased enrollment will require the hiring of 2.2 million new teachers in the next decade. If our preservice institutions do not transform their programs, these educators will be prepared to teach in a system that no longer exists. The complete and rapid transformation of preservice education can be facilitated by changing the criteria through which accreditation is offered. Institutions that fail to meet the new criterial will lose their accreditation.

Third, we need a goal that states the need for every learner and educator to master three fundamental skills mentioned before for the effective use of the web: knowing how to find information, how to determine its relevance, and how to determine its accuracy. If this skill can be applied to web-based information, it can be applied to information in any form. These are foundational skills for everyone in the coming years and they need to be mandated. (For example, they would be foundational skills taught in both preservice and inservice education for all teachers.)

Fourth, we need to redouble our efforts to insure that every learner has universal access to telematic learning tools. As described later in this document, the digital divide is widening. I know of no faster way for the United States to collapse into a third world economy than to allow this trend to continue.

Fifth, we need to continue and expand projects that bring rich educational materials in the public domain to all. The American Memory Project of the Library of Congress is but one exemplary example, as is the work of NASA and other governmental resources. The continuation and expansion of projects like FREE (http://www.ed.gov/free) will contribute to this effort. In developing these resources, it is essential to link our efforts with those of other countries to help build awareness and understanding of other cultures to all our learners.

Above all, we need to acknowledge that technology use, per se, is not the point. How technology is used is more important than if it is used at all. Toward this end, deep structural changes in education can be supported with technology use as we make the shift from "learning *about" to "learning by doing," from reception to construction of knowledge,* from institutions to learning communities, and all the other transformations required of 21st century society.

Whatever goals we choose, they should be visionary. As Gil Noble once said, "The biggest enemy of excellence is 'good enough'." If we expect excellence from our learners, we need to expect it from our teachers and institutions as well.

- **How can we, as a nation, achieve the technology goals for the future?**

In a letter to James Madison in 1787, Thomas Jefferson wrote:

> "I hold it, that a little rebellion, now and then, is a good thing, and as necessary in the political world as storms in the physical."

In education, the time for a "little rebellion" is at hand. We must continue to develop bold visions for the future built on an understanding that the future will not be an extrapolation of the past. We must recognize that our institutions must serve the society in which they exist.

The United States of the twenty-first century will be very different from what it was in the nineteenth century when our current model of schooling reached full flower. Unless we change our schools to meet the needs of the new century, they will cease to be relevant in the education of our youth and will be replaced by those who can not afford to preserve the status quo in a highly competitive global economy moving at Internet speed.

The role of the Federal government should be to help the American public understand the need for a deep systemic transformation of our educational system. For many years we have been telling the public that education needs to be changed, but much of this conversation has focused on the need to achieve better results in student learning without addressing the deeper structural and systemic issues that define our schools. Unless we aggressively work to transform the very structure of schooling, all our efforts to improve student performance will fall short. The educational system of today was never designed to educate the entire populace to high levels of mastery. It was not designed to be flexible enough to adapt to a world moving at today's pace. It is, in fact, a miracle that our schools have done as well as they have. The fundamental structure of schooling is almost antithetical to the learning needs of the next century. We should not be surprised that we are doing poorly; we should be impressed that we have done so well.

We need a "little rebellion". We need to engage all stakeholders in our communities in conversations about education and learning in general. We need to understand that everyone at any age is at least a part-time learner, and explore ways that the learning needs of our communities can best be addressed. Diverse perspectives will be presented, and all should be heard, but the fundamental question remains the same: "What should educational institutions be like if they are to meet the learning needs of those who will live and work in the twenty-first century?"

The Federal government can play a significant role in keeping this question in the public's mind, in funding projects in support of this transformation, and in encouraging communities to take a leadership role in preparing all learners for the coming years.

The main message to be conveyed is simply this: *We must prepare learners for their future, not for our past.*

This task will be hard to achieve. Schooling is one of the few activities that every citizen experiences. As a result, we each have a vision of what school is like, based on our own experiences. Understanding that this comfortable recollection from our youth describes a system that met the needs of a very different time is hard. Many will claim that we need to go back to some romanticized notion of "basic education," and that our problems would all be solved if we just stopped "messing" with the system. Preservice instructors will have to completely transform their curriculum and teaching methods. The design of new schools will need to reflect the new model of education needed to prepare young people for their dynamic future. The fact is that the world outside of school has changed so much as to be largely unrecognizable to our grandparents, yet many persist in the belief that we can keep our schools the same and still help learners acquire the new skills they need for a world moving at light speed.

One definition of insanity is to keep doing the same thing while expecting different results. The only way we will address the needs of today's youth is to be agressive in transforming our educational system to meet the needs of the next century.

In other words, our challenge will be to help the public understand that *when you travel at the speed of light, you don't need a rearview mirror.*

➢ **What else should we, as a nation, be paying more attention to that we are not?**

The vision presented in this document is (I hope) far-reaching, but it is likely to be meaningless unless we address the very severe inequities in technology access that exist today. In the most recent (1999) release of *Falling Through the Net: Defining the Digital Divide*, a document from the National Telecommunications and Information Administration (http://www.ntia.doc.gov), some sobering statistics show just how great the challenge has become:

- Households with incomes of $75,000 and higher are more than twenty times more likely to have access to the Internet than those at the lowest income levels, and more than nine times as likely to have a computer at home.
- Whites are more likely to have access to the Internet from home than Blacks or Hispanics have from any location.
- Black and Hispanic households are approximately one-third as likely to have home Internet access as households of Asian/Pacific Islander descent, and roughly two-fifths as likely as White households.
- Regardless of income level, Americans living in rural areas are lagging behind in Internet access. Indeed, at the lowest income levels, those in urban areas are more than twice as likely to have Internet access than those earning the same income in rural areas. For

many groups, the digital divide has widened as the information "haves" outpace the "have nots" in gaining access to electronic resources.

- The gaps between White and Hispanic households, and between White and Black households, are now more than six percentage points larger than they were in 1994.
- The digital divides based on education and income level have also increased in the last year alone. Between 1997 and 1998, the divide between those at the highest and lowest education levels increased 25 percent, and the divide between those at the highest and lowest income levels grew 29 percent.

None of this is meant to suggest that the increase in access by highly educated, affluent citizens is bad — on the contrary, it is wonderful. The problem is that access among the poor, minorities, and citizens in rural America is not growing as rapidly, further widening the gap between the information haves and information have-nots. Until every home can afford access to information resources, we will need public policies and private initiatives to expand affordable access to those resources.

Beyond that, it is important to understand the role schools can play in addressing inequities. America's schools reach all young people, rich, poor, people of color, those who live in rural areas — everyone. If our schools are equipped with the modern technologies of information and communication, they can serve as resources not just to our children, but to the community at large. This expanded role of schools as community access centers also fits with the reality that we have entered an era where lifelong learning is a necessity, not a luxury. Schools available to all, open day and night, can become the common meeting ground for communities — places where we see the power of a democratic society in action. What better force can one imagine to bring people together in pursuit of the continued development of our free society than such places? Schools where young and old can learn, places where ideas can be shared, leverage points for economic development — all these and more become possible when we re-envision schools as active wired community access points to the entire planet. A technology plan connected to the redefinition of schooling is a wonderful gift for this millenium to provide to the next.

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Prior to working in education, David was one of the first members of the Xerox Palo Alto Research Center and the co-founder of two small companies in Silicon Valley. He currently splits his residence between San Francisco, California and Recife, Brazil.

White Papers

Extracurriculars as the Curriculum: A Vision of Education for the 21st Century

By Roger Schank

The education system in our country, based for too long on the pedagogically invalid "factory model," is in dire need of an overhaul. Thankfully, technology is on the verge of fundamentally reshaping the American education system. In particular, the technology to deliver full-length courses is rapidly becoming a reality, and the impact will be pervasive. The early signs of this change are already visible. I see technology driving educational change in the following key areas:

- **New role for teachers.** The availability of courses delivered over the web will lead to a shift in teachers' responsibilities from teaching academic subjects to teaching social and interpersonal skills. All academic subjects will be taught online and, as a result, teachers will no longer be expected to be experts in these subjects. Instead, the role of teachers will evolve into one that combines the skills of a social worker, guidance counselor, and camp counselor, with teachers no longer being authority figures but rather learning facilitators providing one-on-one mentoring.

- **New role for schools.** The schools' most important role will be counterbalancing the social isolation and alienation that will come from the increasing amount of time students will spend in front of computer and TV screens. The role of school will change to become more of a social and activity center where students learn social skills through participation in group activities.

- **Centralization of curriculum and instructional development.** The delivery of education via online courses will change the entire landscape of course development and control of the curriculum. We will be able to realize tremendous efficiencies by developing top-quality courses once, rather than having every teacher in the country repeatedly doing lesson planning for the same courses. The fiction of local control of education will become evident and a panel of experts instead of local groups of well-meaning, but uninformed, parents will develop the curriculum.

This paper elaborates on each of these changes, explains how I see the transformation occurring, and, perhaps most importantly, describes the ways in which the government can act now to facilitate changes that have the opportunity to radically reshape and improve our country's education system.

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EXTRACURRICULARS AS THE CURRICULUM: A VISION OF EDUCATION FOR THE 21ST CENTURY

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INTRODUCTION

The education system in our country, based for too long on the pedagogically invalid "factory model," is in dire need of an overhaul. Thankfully, technology is on the verge of fundamentally reshaping the American education system. In particular, the technology to deliver full-length courses is rapidly becoming a reality, and the impact will be pervasive. The early signs of this change are widely visible; where these changes will take us, how the roles of schools and teachers will change in the 21st century, and what our government should do to foster this change is the focus of this paper. Perhaps one of the most surprising things is the direction this change will come from.

I see technology driving educational change in the following key areas:

- **New role for teachers.** The availability of courses delivered over the web will lead to a shift in teachers' responsibilities from teaching academic subjects to teaching social and interpersonal skills. All academic subjects will be taught online and, as a result, teachers will no longer be expected to be experts in these subjects. Instead, the role of teachers will evolve into one that combines the skills of a social worker, guidance counselor, and camp counselor. Teachers will move away f.om a role of authority figure to one of a learning facilitator or guide as well as providing one-on-one mentoring.

- **New role for schools.** The widespread availability of online courses outside of school will lead to a fundamental change in the role of schools as well. The schools' most important role will be counterbalancing the social isolation and alienation that will come from the increasing amount of time students will spend in front of computer and TV screens. The role of school will change to become more of a social and activity center where students learn social skills through participation in group activities.

- **Centralization of curriculum and instructional development.** The delivery of education via online courses will change the entire landscape of course development and control of the curriculum. We will be able to realize tremendous efficiencies by developing top-quality courses once, rather than having every teacher in the country repeatedly doing lesson planning for the same courses. The fiction of local control of education will become evident and a panel of experts instead of local groups of well-meaning, but uninformed, parents will develop the curriculum.

This paper elaborates on each of these changes, explains how I see the transformation occurring, and, perhaps most importantly, describes the ways in which the government can act now to facilitate changes that have the opportunity to radically reshape and improve our country's education system.

ONLINE DELIVERY OF COURSES WILL DRIVE CHANGE

The primary driver of change in the 21st century education system has already been created. It is the creation and delivery of courses over the web. Those familiar with this area know that it is about to undergo explosive growth. Companies are already jockeying for position in this marketplace, and many more are entering it every day. Venture capital is pouring in. These online courses will first be developed for the university and continuing education marketplace, and from there they will gradually be adopted in secondary and primary education venues. Don't get confused by what these courses look like today. Now we are seeing the equivalent of the filmed plays of the early movie making era. This will not be the case for long. Soon there will be high quality major productions. The bottom line is that traditional academic courses are no longer going to be taught by local teachers. The computer will allow the creation of learn by doing courses rather than learn by telling courses. The computer will allow the designers of these courses to be the best and the brightest in any given field. Moreover, these courses will be very engaging, non threatening, diverse, and fun. Once the very best physicists in the world sit down and create a physics course, there will be little use for local physics teachers. This will soon happen as investors seeing the rise in internet stocks begin to enter the education market. The same will be true for every academic subject and for many subjects that are not now seen as academically relevant. Companies will create courses and guarantee employment to those who pass them. Quality universities will put their names on these courses. This will create tremendous change for everyone involved in the education system, from students to teachers to administrators to government education agencies.

NEW ROLE FOR TEACHERS

The teaching of traditional academic subjects, first in high school and later in elementary school as well, will be increasingly done via online courses. Once the initial set of these courses becomes successful, there will be more of a push to make the technology available and people will be increasingly accepting of them. Eventually what you'll have in school is a library of hundreds of these courses. The teachers are going to have to do things that the teachers themselves are better at doing than the computer. What can they do better? What they can do better is personal one-on-one tutoring; teaching kids how to work in a group trying to accomplish something; teaching crucial interpersonal relationship skills. Looking at Littleton and all the other school shootings it's obvious that the schools should be stressing the kinds of things children and adolescents really need to learn. How to get along with each other. How to communicate better. How to deal effectively with stress. How to function in society.

The role of teachers is going to evolve away from being the expert in math, science, and other subjects. We've been evolving that way for a long time. Today, most high school teachers could hardly claim to be the expert in physics or history or literature in their communities. In the future, the best minds in the country, in the whole world, will be sitting there at your desktop. The initial knee-jerk reaction is likely to be that schoolteachers are going to feel disenfranchised. But there is an opportunity to start teaching those social skills that students desperately need. I think what's going to happen is that teachers are going to understand they can do a better job in these areas. A lot of teachers are doing it already, even though it is rarely part of the formal curriculum.

They do it because they have to do it. In the future, these social skills will become the central focus of what teachers will teach. Today there is a push to measure teachers by the test scores achieved by their students. Tomorrow, teachers will be judged by more meaningful measures as we begin to value teachers for their human qualities.

The trends we currently see in this country only reinforce the need for this change in teachers' roles. Children are growing up in households where one or both parents are working all kinds of hours, leaving little time to provide the kind of guidance children need. Teachers will increasingly be needed to step into this role, and the sooner we as a society acknowledge it, and address this need openly and honestly, the sooner we will be able to effect positive change. I'd like to see the teachers really seriously trained in social work and guidance counseling. They need to understand how to effectively deal with a wide range of psychological problems. This is really a failure of our current approach to education. We need teachers who are specifically trained to remove their own personal feelings about a student and understand how to deal with that student in a complex situation.

Not only will teachers act much more as social workers or guidance counselors, but also they will lead courses that explicitly focus on developing social and interpersonal skills. In many ways these course will resemble the kinds of programs provided by Outward Bound. Let students participate in teams and deal with the team decisions that have to be taken care of. The students go off on a trip and they try to accomplish something. The teacher becomes an advisor to the team, or a guide on an expedition.

I have always believed that summer camp is a more valuable experience than school. Certainly many children look back on their summer camp experiences with much greater fondness than their school experiences. Personal growth takes place more easily at camp and personal growth is what high school ought to be about. With so many students going to college, high school as a kind of watered down college is really an archaic idea. So, I say let school become camp. At summer camp, the counselors have to get the kids to function together. The model of camp counselor is very valid for the role that teachers will assume. Right now teachers are authority figures. They have the power to assign grades, to pass or fail students. This is why teachers for the most part are bad guidance counselors or team leaders. A camp counselor who doesn't have that power over students is actually more useful, specifically because the authority relationship is completely different. Once teachers move out of this authority role, they will eliminate a roadblock that prevents them from connecting with the students who need the most guidance.

CHANGES IN PRIMARY EDUCATION

The changes in elementary schools will be similar to those I envision for high school, with variations in the relative proportion of time devoted to academic subjects vs. social interaction. As I described above, I think you should take every subject by computer when you're in high school and everything else should be about social and interpersonal issues. In elementary school I think that the academic subjects that are taught by computer are the basics, the three 'R's. The other things ought to be taught by people. Kids should spend less time sitting in front of a computer. I don't think little kids should be sitting much. I think they should be going out and doing stuff and exploring the world and talking about it. That's what I'd like to see them do. There's plenty of time for them to sit later.

In fact, one of the biggest problems we have in elementary school is the amount of time kids are forced to sit still. It's so hard, it's the last thing they want to do. I'd rather see the kids play a lot and have a little bit of instruction. I'd like them to be spending more time playing than doing academics. I think the idea that you're going to sit down and instruct a seven-year-old with something complex is a real problem. A seven-year-old can sit there and do endless math examples but what we are really teaching is how to follow instructions and how to sit for long periods of time. This was originally part of the scheme of training factory workers. While I think there is a valuable lesson in teaching a seven-year-old to sit down and focus on a task, it shouldn't be about doing fourteen hundred multiplication tables. In the old days they'd send eight-year-olds out to work real jobs and in some ways they weren't worse off for it. They were worse off for having their childhood taken away and they were worse off for being in sweatshop conditions that were oppressive. Yet many of them succeeded very well in life by learning good work habits early. To a large extent I think that's what elementary school should be about. It should be about reading, writing and arithmetic and good work habits. Also it should be about instilling a love of learning. So, the software should be available for the curious to follow wherever their interests take them.

Think about what parents do when they have a six-year-old at home. They build stuff, they draw stuff, and they look at stuff. Parents don't sit down and try to tell them something. They interact. You want kids to be physically engaged in activities. It's the sitting them down that's torture. When we sit them down we think we're going to instruct them. Well, get over it. We don't have to instruct them. We should focus on the basics that kids have to come out of elementary school with so that they are prepared to begin taking the online courses they will get in high school. Aside from the basics of reading, writing and arithmetic, learning in elementary school should focus on core skills such as communication, human relations and reasoning. All those can be done without sitting down. You can go to the zoo and learn how to communicate, to relate to others, and to reason. Students should learn how to stand up in front of people and talk about their ideas. You can only learn how to develop these kinds of public speaking skills by practicing them a lot.

In addition to field trips, I envision team sports as a bigger part of the school day, much as it is in summer camp. A lot of what in today's school system is considered extracurricular, like putting out a school paper, ought to *be* the curriculum. You learn more that way than any other way. The extra-curriculars should become the curriculum.

The other advantage that comes from the accessibility of courses online is that students will be able to learn about topics that interest them at their own pace. I don't think primary school students need to be taking courses with their peers, but a lot of instruction should be available to them. Today, many of our bright elementary school students are bored and would like to be able to go take high school courses. For practical reasons, like scheduling and transportation, this almost is never permitted. Soon all of these high school·courses will be available online, and there won't be any compelling reason why students of any age who are ready for them couldn't take them.

Every year there is a story in the paper about an eight- or twelve-year-old who is going to college. The typical reaction to this story is: Oh, my God. Why? Not because people are worried that he or she can't handle the intellectual issues. People are worried he or she can't handle the social issues. With the advent of online courses we will be divorcing the intellectual issues from the social issues. Any child at any age who is intellectually ready can take a high school or college course. They can take calculus when they're six if that's what they're ready for.

NEW ROLES FOR SCHOOLS

The role of schools will change in ways similar to the changes in teachers' roles. As I've said, one of the really big problems we have coming in the future of this country is a tremendous social alienation problem. We are moving in a direction where everybody is staring at a computer or a television all day and all night and not interacting with other people in a meaningful way. I think the schools will have to be the counterbalance to this trend, to actively provide opportunities for social interaction and to teach the skills required for successful interaction with other individuals and within a group or team. If not, we will see more school shootings. Part of the job of the school is to help students learn how to work together and to be a functional part of society.

The school itself will evolve into a sort of student or community center, where kids are engaged in a variety of activities and projects. Perhaps they will be on a team building houses for disadvantaged members of the community, or maybe going out on a trip or having a discussion. There will be a tremendous range of activities, but these will not be purely academic activities as they are currently. When students are not participating in these activities they will be taking courses online at home, or if the supervision doesn't allow it, at school. Schools will provide the space and resources for students to access the online courses. I don't think there is any need for classrooms. I think that they're an archaic idea, although it will take a while to get rid them.

With schools serving as more of an activity or community center, I think that we will see them becoming much more connected to the community around them. Student activities will involve working on community service projects that bring students into contact with the community they live in. Schools will also become more connected to local businesses, as students have the opportunity to engage in real-world jobs with local employers. The school will become the center of the community, in a much deeper way than it currently is.

CENTRALIZATION OF CURRICULUM AND INSTRUCTIONAL DEVELOPMENT AND ACADEMIC TUTORING

The advent of ubiquitous networking technology will lead to the centralization of key functions in the education system, just as it has in the business world. I see this happening in three key areas.

First, the delivery of education via online courses will change the entire landscape of course development and control of the curriculum. Each academic field will supply its experts to help create the courses in that field. Once these courses are created, the notion that a teacher at a local school should be creating their own course no longer makes any sense whatever. Consortiums of academic experts, educational technologists, and businesses will work to develop, update, refine, and improve these courses. As a society, we will be able to realize tremendous efficiencies by developing these top-quality courses once, rather than having every teacher in the country repeatedly doing lesson planning for the same courses.

In addition to eliminating the redundant effort of reinventing the same courses across the country, we will also realize a tremendous improvement in quality control of the courses. The era where we have countless numbers of students who have been turned off on physics, math, chemistry, or literature because of poor teachers teaching bad courses in these subjects will be over. Every student in the country will be able to select from a wide range of top-quality courses in any subject that interests them.

Second, the fiction of local control of education will become evident and a panel of education experts instead of local groups of well-meaning, but uninformed, parents will develop the curriculum. What will be the point of local school boards arguing over which courses should or should not be offered, when every imaginable course is available? A central body, comprised of the country's best experts on education and learning, with representatives from the various academic fields, will assume control over the curriculum represented by the online courses.

Third, the advance of technology, in particular live videoconferencing, will lead to the creation of a centralized pool of tutors for various subject matters. Just as today's companies have centralized phone centers where customers can call in for service, we will see the creation of one-on-one tutoring services provided via live videoconferencing. Having trouble with some calculus problems? Just connect to the calculus tutoring center for a face-to-face session with an expert tutor. These learning service centers will provide students across the country, no matter what community they live in, with access to the best coaches available to help them with their work in the online courses.

HOW IT WILL HAPPEN

The changes I envision for 21st century education will happen gradually. But the seeds of these changes have already been planted. Universities, and their partners, are beginning to develop online courses. Increasing sums of money are being spent on these courses, and we will soon see a fair number of online courses. However, the impact of these online courses will soon begin to be felt at the secondary, and eventually, the primary levels too. How will this happen?

Initially, progress will be slow. For example, right now a physics professor who wants to put their introductory physics course online usually just puts his or her lecture notes and some quizzes or tests online. That just makes the course worse. But, what eventually will happen is that the course is going to improve. Physicists and educational technologists will sit down to redesign the physics course and ask the important questions. For example, what should physics be teaching you? We will see the best and the brightest redesign these types of courses and—with enough money available—you will have some phenomenal multimedia courses published online.

Very shortly after they are made available at the university level, these courses will find their way to high school. Why? The most in-demand courses in universities today are the big freshman introductory courses: calculus, biology, physics, economics, psychology, etc. So, from an economic standpoint, it makes sense that these high-enrollment courses are likely to be the first online courses that get developed. But it is these same courses that students are taking as Advanced Placement (AP) courses in high school. So, once these online courses are created, why wouldn't high schools want to adopt them? This will be especially attractive to those schools who can not offer all the AP courses their students wish to take. Eventually, when enough of these online courses are out there it would be possible to take an entire first year of college in high school and receive college credit. Once this happens, the AP system as we know it will disappear. There will be no need to have an arbitrary test determine whether or not you get credit for a course, you can just take the same course college freshmen are taking and get college credit directly.

To the extent that these AP-level courses are successful they will begin to be developed for other high school courses as well. It's not going to happen all of a sudden. One day a high school principal will say, "We don't have any new teachers for our business course, so we'll take the college level business course, which Columbia is offering." Or, "We have never been able to offer a course in psychology, but now there is a college level course in psychology that we can let our students register for." Perhaps initially, high schools will allow students to take one course a year online. At first they will be for electives or optional courses. Well, students will soon be questioning why they can't take two courses online, especially if they are better than the existing courses. These students will want to take the college level courses because they can get college credit. No high school can sit there and say you can't do it. They're available. Students who are determined to take these courses can do them at home, independently of their high school's policies. The availability of online courses in high school is going to happen slowly, but it's going to happen. It has to happen. It's easy to imagine that it may not be the case in two years, but it's much less easy to imagine that it won't be the case in five years.

The availability of these online courses will cause a tremendous gap in the high school system. If you have really first rate AP courses taught online, and enough of them out there, the actual high schools themselves will become less important. Why take high school physics if you can take college physics courses? If the high school physics course didn't necessarily prepare you for college, maybe there isn't a need for high school physics at all. It may be possible to build a set of courses to cause the curriculum in high school to have to change. My argument about high school curriculum is that they're teaching the wrong material in many cases. The materials that they are teaching are basically watered down college courses. Once authentic college courses are available to high school students online, the entire content of the high school curriculum will be called into question. Of course, the college courses aren't necessarily teaching the right stuff either. This too shall change. Competitive forces will cause more practical and relevant courses to be built and soon college introductory courses will focus on how to run a business rather than the theory of micro-economics or how to use chemistry as a doctor rather than principles of organic chemistry.

With increasing numbers of high school students flocking to take the high-quality online courses, for which they can receive college credit, the traditional courses will find themselves with depleted enrollments. High school teachers will feel disenfranchised and will undoubtedly push back against this trend. This will be a painful period for many high school teachers. But as I described above, this will be a period when the role of a high school teacher will undergo a transformation to someone who is trained to deal with students' psychological and social interaction needs. While there will be resistance to change, the change will happen nonetheless.

WHAT THE GOVERNMENT'S ROLE SHOULD BE

The tremendous changes that technology will bring to our education system will necessitate an equally radical change in the role the government should play. Initially, I see four key things the government can do to facilitate needed changes in our education system. They are:

- Changing from a focus on goal and standard setting to a more active role in recruiting the country's best experts and designing the best online courses.

- Supporting development of courses, particularly those that may not be economically viable for the private sector to create.

- Investing in new software technologies that can facilitate online learning and interactivity.

- Thinking about and planning for a vision of school that does not revolve around, or even include, classrooms. The government should begin to pilot test the new role of school as activity center even before all the technology is available.

ACTIVIST ROLE

One of the most important things the government must do is to rethink the limitations imposed on the Department of Education from exercising direct control over curriculum decisions at the local level. At some point the federal government has to understand what its job really is. The idea that local education is being run by a group of well-meaning, but uninformed parents on a school board is insane. They don't know what they should be teaching. The whole idea that we have a local school board in control of education is so much of a farce because they don't really have control. The control is really in the hands of book publishers and the Educational Testing Service. The federal government has to get involved with this.

The government must take an active role in recruiting the country's best experts and working with them to design the best online courses. The private sector may have more or less success recruiting these experts. But I think if the federal government decided to get all the physicists in front of cameras to get their physics knowledge, it would be much more likely to succeed. There will be a tremendous amount of prestige associated with being asked to help shape the physics course that all the students in the country will take.

But this requires the government and the Education Department in particular, to move away from a focus on goals and curriculum standards towards helping to shape the curriculum and courses themselves. Let's face it, the government's standard setting is just a thinly disguised way of influencing the curriculum anyway. To help guide this country's education system into a new, and much more productive, paradigm, the government must take an activist role. In other words, it must lead, not follow.

SUPPORTING DEVELOPMENT OF COURSES

A second important role for the government to play is by supporting the creation of online courses that are not economically viable for the private sector to build. For example, I think there ought to be a yearlong course for all college students that provides an introduction to medicine. But, the private sector is not going to build that course, at least not for a while. The reason is that course builders have to work within the demands of the existing system. There isn't a place for new or innovate courses right now. There are subject matters that are off the mainstream that are going to take ages for anyone to build a course about. Pre-med and business schools will be much higher up on the list. I think it's important for the federal government to pick up the slack and fund course development in the areas that aren't commercially viable. I'd like there to be thousands of courses. I'd like to see courses that only twenty-five people per year would ever take. Without support from the government, the range of course offerings will be much more constrained by economics than it should be.

INVESTING IN SUPPORTING TECHNOLOGIES

The Federal Government should also start spending a serious amount of money investing in areas that will support the creation and delivery of online courses, for example, areas that are very speculative or are very out in left field or require new technologies to build. The universities would research that sort of thing if the federal government understood it and funded it. Suppose you are building a national story archive that captures every important person in the country on video. Having such an archive available would tremendously accelerate the creation of high quality online courses. The private sector probably isn't going to do it. The government should fund projects that will contribute to the improvement and advancement of online courses, projects like the development of online simulations and the expansion of expert video databases.

EXPERIMENTING WITH NEW APPROACHES TO SCHOOLING

Finally, I believe the government is not paying any attention to understanding how to get rid of classrooms. There is still the sense that the classroom is going to continue to suffice as a locus for education. With the advent of online courses, and the changes they will bring to education—from elementary through post-secondary—the era of the classroom is over. The government should begin to study new conceptions of school. And those studies should begin now. There is no need to wait until every course is available online. The government should experiment now with schools that separate the roles of academic learning and social skills even before courses are all online. Start building a school based on an Outward Bound type model, or one that is based on a summer camp model and staffed with teachers trained in dealing with social and interpersonal issues. The time to work out the kinks in this new approach to schooling, to understand the kinds of skills teachers will need, and to determine the kinds of buildings we will need and the resources they will require, is now.

CONCLUSION

The primary driver of change in our education system in the 21st century will be the creation of online courses that will remove from teachers the responsibilities for teaching academic subjects. Instead teachers and schools will focus on combating the increasing social isolation that our society will face. Schools will become activity centers where students work in groups on real-world projects, go on trips, and participate in the community. While students may also use schools as locations to engage in online course work, this course work will be just as available at home.

The advent of online courses and associated networking technology will also lead to a centralization of course and curriculum development. The federal government will need to step into a leadership role to insure that the students of our country benefit from the highest-quality curriculum we can create, informed by our country's leading experts. The Internet economy has created the "first movers advantage"—the first to enter a new marketplace often maintains an advantage over competitors. Our country must seize the opportunity to be the "first movers" in creating a new approach to education.

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Rewiring The History And Social Studies Classroom: Needs, Frameworks, Dangers, And Proposals

By Randy Bass and Roy Rosenzweig

Our paper asks four basic questions about new technology in social studies: 1. what we are trying to accomplish? 2. what approaches will work best? 3. are there dangers that we need to avoid? 4. how can we encourage and support the adoption and development of the best practices?

1. Needs

We usually begin technology workshops with teachers by asking: "What are you doing now in your teaching that you would like to do better? Most commonly, they say they want their students more engaged with learning; they want students to construct new and better relationships to knowledge, not just represent it on tests; and they want students to acquire deeper more lasting understanding of essential concepts. Despite the current emphases on factual learning in history and social studies, we believe that such factual knowledge emerges out of active engagement with learning rather than out of textbook and test-driven curriculum. Working from that premise, the problem we seek to address is how can the social studies classroom become a site of active learning and critical thinking? Can technology help?

2. Frameworks

Our work with teachers leads us to conclude that the most successful educational uses of digital technology fall into three broad categories: **Inquiry-based learning** utilizing digitized and multimedia primary sources, involving different senses and forms of expression and addressing different learning styles; **Bridging reading and writing through on-line interaction**, extending the time and space for dialogue and learning, and joining literacy with disciplinary and interdisciplinary inquiry; **Making student work public in new media formats**, which encourage the exchange of knowledge-representations and create opportunities for review by broader professional and public audiences.

3. Dangers

It would be foolish to suggest that technology is either a panacea for the problems of social studies education. Moreover, any change in a complex environment needs to be thought about*ecologically*. Other dangers include the use of software that encourages passivity rather than interactivity, the focus of resources on hardware and software to the exclusion of professional development for teachers, the possibility that technology could widen rather than narrow economic gaps between schools and students, and the belief that technology is an end in itself rather than a means to achieving better student learning.

4. Proposals

We offer six (immodest) proposals in conclusion:

- a renewed national commitment to insuring that the benefits of new technology be shared equally;
- revised assessment to accurately measure learning in the new media environment.
- the development of more tools and supports that will enable teachers to use electronic resources actively and critically;
- robust professional development programs that will allow teachers to retool for the electronic future.
- pre-service education that goes considerably beyond courses on new media and teaching methods.
- serious classroom research into what does and doesn't work.

Click here to view Rewiring The History And Social Studies Classroom: Needs, Frameworks, Dangers, And Proposals in pdf format.

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ED HOME ED HOME Technology

REWIRING THE HISTORY AND SOCIAL STUDIES CLASSROOM: NEEDS, FRAMEWORKS, DANGERS, AND PROPOSALS[i]

By Randy Bass, Center for New Designs in Learning and Scholarship, Georgetown University, and Roy Rosenzweig, Center for History and New Media, George Mason University

Within five years of Alexander Graham Bell's first display of his telephone at the 1876 Centennial Exposition, *Scientific American* promised that the new device would bring a greater "kinship of humanity" and "nothing less than a new organization of society." Others were less sanguine, worrying that telephones would spread germs through the wires, destroy local accents, and give authoritarian governments a listening box in the homes of their subjects. The Knights of Columbus fretted that phones might wreck home life, stop people from visiting friends, and create a nation of slugs who would not stir from their desks[ii]

Extravagant predictions of utopia or doom have accompanied most new communications technologies, and the same rhetoric of celebration and denunciation has enveloped the Internet. For *Wired* magazine publisher Louis Rossetto, the digital revolution promises "social changes so profound that their only parallel is probably the discovery of fire." According to Iraq's official government newspaper, *Al-Jumhuriya*, the Internet spells "the end of civilizations, cultures, interests, and ethics."[iii]

The same excessive rhetoric has surrounded specific discussions of computers and education. "Thirty years from now the big university campuses will be relics," proclaims Peter Drucker in *Forbes*. "It took more than 200 years (1440 to the late 1600s) for the printed book to create the modern school. It won't take nearly that long for the [next] big change." One advertisement on the Web captures the mixture of opportunity and anxiety occasioned by the new technology. Three little red schoolhouses stand together in a field. A pulsing green line or wire lights up one of the schools with a pulse of energy and excitement, casting the others into shadow. "Intraschool is Coming to a District Near You," a sign flashes. "Don't Be Left Behind!" And the other side has similarly mobilized exaggerated forecasts of doom. Sven Birkerts, for example, laments new media as a dire threat to essential habits of wisdom—"the struggle for which has for millennia been central to the very idea of culture."[iv]

There are some encouraging recent signs that the exaggerated prophecies of utopia or dystopia are fading and we are beginning the more sober process of assessing where computers, networks, digital media (our working definition of "technology") are and aren't useful. Rather than apocalyptic transformation, we seem to be heading toward what Phil Agre calls the "digestion model." "As a new technology arises," he observes, "various organized groups of participants in an existing institutional field selectively appropriate the technology in order to do more of what they are already doing—assimilating new technology to old roles, old practices, and old ways of thinking. And yet once this appropriation takes place, the selective amplification of particular functions disrupts the equilibrium of the existing order, giving rise to dynamics internal to the institution and the eventual emergence of a new, perhaps qualitatively different equilibrium."[v]

In social studies education, we have already begun the process of "selective appropriation" of technology.[vi] But before we can move to a new and hopefully better equilibrium, we need to ask some difficult questions. First, and most important: what we are trying to accomplish? Second, what approaches will work best? Third, are there dangers that we need to avoid as we selectively appropriate new technology into the social studies classroom? Fourth, how can we encourage and support the adoption and development of the best practices?

1. Why Use Technology in Social Studies Education?

Over the past five years of running technology workshops with hundreds, if not thousands, of college and pre-college teachers, we have usually begun by asking them: "What are you doing now in your teaching that you would like to do better? What do you wish your students did more often or differently?" "What pedagogical problems are you looking to solve?" Most commonly, they say they want their students more engaged with learning; they want students to construct new and better relationships to knowledge, not just represent it on tests; and they want students to acquire deeper more lasting understanding of essential concepts.

Such responses run counter to another public discourse about social studies education—the worry, if not alarm, about student knowledge of a body of factual material. "Surely a grade of 33 in 100 on the simplest and most obvious facts of American history is not a record in which any high school can take pride," goes a lament that anyone who follows social studies education will find familiar. Indeed, it should be familiar: this particular quote comes from a study published in the *Journal of Educational Psychology* in 1917. As educational psychologist Sam Wineburg points out, "considering the differences between the elite stratum of society attending high school in 1917 and the near universal enrollments of today, the stability of this ignorance inspires incredulity. Nearly everything has changed between 1917 and today except for one thing: kids don't know any history."[vii] Also unchanged is the persistent worry by school boards and public officials about that seeming ignorance.

And yet based on our own experience, this is not the problem that most concerns those teaching in our classrooms (except insofar as curriculum standards and exams constrain innovation and flexibility); neither is the problem that most concerns those who have studied in those classrooms. In 1994, we undertook a nationwide study of a representative cross-section of 808 Americans (as well as additional special samples of 600 African Americans, Mexican Americans and Sioux Indians) that sought to uncover how Americans use and understand the past. We asked a portion of our sample "to pick one word or phrase to describe your experiences with history classes in elementary or high school." Negative descriptions significantly outweighed positive ones. "Boring" was the single most common word offered. In the entire study, the words "boring" or "boredom" almost never appeared in descriptions of activities connected with the pursuit of the past, with the significant exception of when respondents talked about studying history in school—where it comes up repeatedly.[viii]

> The same point came across even more sharply when we asked respondents to identify how connected with the past they felt in seven different situations—gathering with their families, celebrating holidays, reading books, watching films, visiting museums or historic sites, and studying history in school. Respondents ranked classrooms dead last with an average score of 5.7 on a 10-point scale (as compared, say, with 7.9 when they gathered with their families). Whereas one-fifth of respondents reported feeling very connected with the past in school (by giving those experiences a rank of 8 or higher), more than two-thirds felt very connected with the past when they gathered with their families. Of course, the comparison we posed is not an entirely fair one. Schools are the one compulsory activity that we asked about; the others are largely voluntary (though some might disagree about family gatherings). Still, our survey finds people most detached from the past in the place that they most systematically encountered it—the schools.

To be sure, these negative comments about classroom-based history were not always reflected in remarks about specific teachers. Respondents, for example, applauded teachers for engaging students in the study of the past through active learning. A North Carolina man in his mid-twenties, for example, praised a teacher who "got us very involved" because she "took us on various trips and we got hands-on" history. A Bronx woman similarly talked enthusiastically about the "realism" of a class project's engagement with an incident in Puerto Rican history: "Everybody had different information about it, and everyone was giving different things about the same thing, so it made it very exciting."

Although teachers could make history classrooms resemble the settings in which, and the ways that, respondents liked to engage the past, most Americans reported that history classrooms more often seemed to include a content that was removed from their interests and to feature memorization and regurgitation of senseless details. Respondents recalled with great vehemence how teachers had required them to memorize and regurgitate names, dates, and details that had no connection to them. They often added that they forgot the details as soon as the exam had ended. Such complaints could be captured in the words of a 36-year-old financial analyst from Palo Alto, California: "It was just a giant data dump that we were supposed to memorize . . . just numbers and names and to this day I still can't remember them."

Not everyone would agree with these complaints. Others would argue that the real problem of the schools is historical and civic illiteracy—a lack of knowledge of the basic facts about history, politics, and society. Our own view (and that of the teachers with whom we have worked) is that such factual knowledge emerges out of active engagement with learning rather than out of textbook and test-driven curriculum. Given that these are contentious issues, we think that it is important to acknowledge our bias up front. The problem we seek to address is the one that preoccupies the teachers with whom we have worked and the survey respondents with whom we talked—how can the social studies classroom become a site of active learning and critical thinking? Can technology foster those goals?

2. What Works? Three Frameworks for Using Technology to Promote Active Learning

The encouraging, albeit anecdotal, news from the field is that technology has, in fact, served those goals for a number of teachers and students across the country and that there is an emerging body of experience that suggests some of the most promising approaches. Our own framework for categorizing and discussing these approaches grows out of our observation of scores of teachers in workshops sponsored by the American Studies Crossroads Project, the New Media Classroom, and the Library of Congress's American Memory Fellows program.[ix] Based on these interactions, we have concluded that the most successful educational uses of digital technology fall into three broad categories:

- **Inquiry-based learning** utilizing primary sources available on CD-ROMs and the World Wide Web, and including the exploration of multimedia environments with potentially fluid combinations of text, image, sound, moving images in presentational and inquiry activities, involving different senses and forms of expression and addressing different learning styles;
- **Bridging reading and writing through on-line interaction**, extending the time and space for dialogue and learning, and joining literacy with disciplinary and interdisciplinary inquiry;
- **Making student work public in new media formats**, encouraging constructivist pedagogies through the creation and exchange of knowledge-representations, and creating opportunities for review by broader professional and public audiences.

Each type of activity takes advantage of particular qualities of the new media. And each type of activity is also linked to particular pedagogical strategies and goals.

Inquiry activities: the novice in the archive

Probably the most important influence of the availability of digital materials and computer networks has been on the development of inquiry-based exercises rooted in the retrieval and analysis of primary social and cultural documents. These range from simple Web exercises in which students must find a photo that tells something about "work" in the late nineteenth-century to elaborate assignments in which students carefully consider how different photographers, artists, and writers historically have treated the subject of poverty. Indeed, teachers report that inquiry activities with digital materials have been effective at all levels of the K-12 curriculum. In Hillsborough, California, for example, middle school students simulate the work of historians by closely analyzing images of children at the turn of the century that can be found on line. They, then, build from that to a semester-long project that asks students to "construct an understanding of the major 'themes' of the period and how these might impact a child born in 1900." To do that they must assemble a physical and digital scrapbook of letters, images, oral histories, artifacts, and diary entries and think critically about those sources.[x] Similarly, fourth graders in New York use the WPA life histories on line at the Library of Congress to reconstruct the worlds of immigrants, and then use photographs from on-line archives to "illustrate" these narratives in poster presentations. And high school juniors in Kansas City who scrutinize the "Registers of Free Blacks," at the *Valley of the Shadow* Civil War Web site not only to learn about the lives of free African Americans in the Shenandoah Valley before the Civil War, but to reflect on the uses and limitations of different kinds of digital and primary materials to achieve an understanding of the past.[xi]

The analysis of primary sources, and the structured inquiry learning process that is often used in such examinations, are widely recognized as essential steps in building student interest in history and culture and helping them understand the ways that scholars engage in research, study, and interpretation. Primary documents give students a sense of the reality and the complexity of the past; they represent an opportunity to go beyond the predigested, seamless quality of most textbooks to engage with real people and problems. The fragmentary and contradictory nature of primary sources can be challenging and frustrating, but also intriguing and ultimately rewarding, helping students understand the problematic nature of evidence and the constructed quality of historical and social interpretations. Virtually all versions of the national standards for social studies and history published in the 1990s have (in this regard, at least) followed the lead of the 1994 *National Standards for United States History*, which declared that "perhaps no aspect of historical thinking is as exciting to students or as productive of their growth as historical thinkers as 'doing history" by directly encountering "historical documents, eyewitness accounts, letters, diaries, artifacts, [and] photos."[xii]

Of course, the use of primary sources and inquiry methods does not require digital tools. Teachers have long used documentary anthologies and source books (often taking advantage of another somewhat less recent technological advance, the Xerox machine). But the rise of new media and new computer technology has fostered and improved inquiry-based teaching for three key reasons.

First and most obviously is the greatly enhanced access to primary sources that CD-ROMs and the Internet have made possible. Almost overnight teachers, school librarians, and students who previously had scant access to the primary materials from which scholars construct interpretations of society and culture now have at their disposal vast depositories of primary cultural and historical materials. A single Internet connection gives teachers at inner-city urban schools access to more primary source materials than the best-funded private or suburban high school in the United States. Just the sixty different collections (containing about one million different primary documents) that the Library of Congress has made available since the mid-1990s constitute a revolution in the resources available to those who teach about American history, society, or culture. And almost weekly major additional archives are coming on line. These include such diverse collections as the *U.S. Supreme Court Multimedia Database* at Northwestern University (with its massive archive of written and audio decisions and arguments before to the Court); the *U.S. Holocaust Memorial Museum* (with its searchable database of 50,000 images) and *Exploring the French Revolution* at George Mason University (with its comprehensive archive of images and documents).[xiii]

For the history and social studies teacher and the school librarian, even the most frequently criticized feature of the Web—the unfiltered presence of large amounts of "junk"—is potentially an opportunity albeit one that must be approached with care. Bad and biased Web sites are in the hands of the creative teacher fascinating and revealing primary sources. In effect, many skills traditionally taught by social studies teacher—for example, the critical evaluation of sources—have become even more important in the on-line world. The Web offers an exciting and authentic arena in which students can learn to become critical consumers of information. Equally important, the Web presents the student with social knowledge employed in a "real" context. A student studying Marcus Garvey or Franklin Roosevelt through Web-based sources learns not simply about what Garvey or Roosevelt did in the 1920s and 1930s, but also what these "historical" figures mean to people in the present.

A second appealing feature of this new distributed cultural archive is its multimedia character. The teacher with the Xerox machine is limited to written texts and static (and perhaps poorly copied) images. Now, teachers can engage their students with analyzing the hundreds of early motion pictures placed on line by the Library of Congress, the speeches and oral histories available at the National Gallery of Recorded Sound that Michigan State is beginning to assemble, and with literally hundreds of thousands of historical photographs.[xiv]

Third, the digitization of documents allows students to examine them with supple electronic tools, conducting searches that facilitate and transform the inquiry process. For example, the American Memory Collection provides search engines that operate within and across collections; if one is researching sharecropping in the thousands of interview transcripts held in the Federal Writers' Project archive, a search can quickly find (and take you to) every mention of sharecropping in every transcript. Similarly, searches for key words such as "race" or "ethnicity" turn up interesting patterns and unexpected insights into the language and assumptions of the day. In other words, the search engines cannot only help students to find what they are looking for; they also allow them to examine patterns of word usage and language formation within and across documents.

These kinds of activities—searching, examining patterns, discovering connections among artifacts—are all germane to the *authentic thinking processes* of historians and scholars of society and culture. Digital media not only gives flexible access to these resources but also makes visible the often-invisible archival contexts from which interpretive meaning gets made. "Everyone knows the past was wonderfully complex," notes historian Ed Ayres. "In conventional practice, historians obscure choices and compromises as we winnow evidence through finer and finer grids of note-taking, narrative, and analysis, as the abstracted patterns take on a fixity of their own. A digital archive, on the other hand, reminds us every time we look at it of the connections we are not making, of the complications of the past."[xv]

The combination of increased access with the development of powerful digital searching tools has the potential to transform the nature and the scale of students' relationship to the material itself. For the first time perhaps it allows the novice learner to get into the archives and engage in the kinds of archival activities that only expert learners used to be able to do.[xvi] Of course, the nature of their encounter with primary materials and primary processes is still as novice learners. The unique opportunity with electronic, simulated archives is to create open but guided experiences for students that would be difficult or impractical to recreate in most research library environments. It also frees students and teachers from their traditional dependence on place for first-hand social, political, or historical research. Or, perhaps more importantly, it means that students can more readily compare their own community with others, more distant.

The task of creating these open but guided experiences is a demanding one. Teachers must not only learn how to use the new technology, but also spend time exploring the digital archives (perhaps in partnership with school librarians) in order to learn what they hold and consider what students can learn from them. The construction of effective inquiry activities demands knowledge of the topic, the documents, and the archive, as well as the craft of introducing students to the inquiry process. Implementing inquiry approaches in the classroom takes considerable class time—time that teachers are sometimes reluctant to give. And the inquiry process is by definition not easy to control; students are likely to come up with unanticipated answers. At their best, however, new media technologies can help make the "intermediate processes of historical cognition" visible and accessible to learners, in part by helping students approach problem-solving and knowledge-making as open, revisable processes, and in part by providing tools to give teachers—as expert learners—a window into student thinking processes.[xvii]

Bridging reading and writing through on-line interaction

One very significant dimension of "making thinking visible," is the bridging of reading and writing through on-line writing and electronic dialogue. Again, the benefits of writing and dialogue for student learning were well established before the emergence of computers and the Internet. Over the last several decades, educators in many disciplines and at every level of education have come to believe that meaningful education involves students not merely as passive recipients of knowledge dispensed by the instructor, but as active contributors to the learning process. One of the key elements in this pedagogy is the importance of student discussion and interaction with the instructor and with each other, which provides opportunities for students to articulate, exchange, and deepen their learning. Educators in a wide range of settings practice variations of this process.

But the emergence of digital media, tools, and networks has multiplied the possibilities. Electronic mail, electronic discussion lists, and Web bulletin boards can support and enhance such pedagogies by creating new spaces for group conversations.[xviii] One of the greatest advantages to using electronic interaction involves the writing process, which can facilitate complex thinking and learning as well as build related skills. These advantages can combine with the potential for electronic discussion to draw out students who remain silent in face-to-face discussion. On-line interaction has also proven to be effective in helping to build connections between subject-based learning and literacy skills (reading and writing) which too often are treated separately.

On-line discussion tools also foster community and dialogue. Active, guided dialogue helps involve students in the processes of making knowledge, testing and rehearsing interpretations, and communicating their ideas to others in "public" ways. Yet another advantage to on-line dialogue tools is in helping students make connections beyond the classroom, whether it is enhancing the study of regional and national history through connections with a classroom elsewhere in the United States, or enhancing global social studies curricula through email "penpal" programs with students elsewhere in the world. Postcard Geography is a simple project, organized through the Internet, in which hundreds of classes (particularly elementary school classes) learn geography by exchanging postcards (real and virtual, purchased and computer generated) with each other. An Alabama elementary school teacher notes the galvanizing effect of the project on her rural students who "don't get out of their city, let alone their state or country!"[xix] At North Hagerstown High School in Maryland, high school students mount on-line discussions of issues like the crisis in Kosovo, engaging in dialogue among themselves and with more far-flung contributors—from Brooklyn to Belgrade.[xx].

Designing constructive public spaces for learning

Closely connected to both on-line writing and inquiry activities is the third dimension of our framework: the use of constructive virtual spaces as environments for students to synthesize their reading and writing through public products. As with the other uses of new technology, the advantages of public presentations of student work are well known. But, here again, the new technology—in particularly the emergence of the Web as a "public" space that is accessible to all—has greatly leveraged an existing practice. Virtual environments offer many layers of public space that help "make thinking visible" and lead students to develop a stronger sense of public accountability for their ideas. The creation of public, constructed projects is another manifestation of these public pedagogies, one that engages students significantly in the design and building of knowledge products as a critical part of the learning process.

In the use of new media technologies in culture and history fields, "constructivist" and "constuctionist" approaches provide ways for students to make their work public in new media spaces as part of the learning process, ranging from the individual construction of Web pages to participation in large, ongoing collaborative resource projects that involve many students and faculty over many years development.[xxi] For example, at an elementary school in Virginia, fifth graders studying world cultures build a different "wing" of a virtual museum each year, research and annotating cultural artifacts, and then mounting them on line; similarly, at a middle school in Philadelphia sixth graders worked closely with a local museum to create a CD-ROM exhibit on Mesopotamia, using images and resources from the museum's collections.[xxii] Seventh graders in Arlington, Virginia published an on-line "Civil War Newspaper" with Matthew Brady photographs from the Library of Congress as well as their own analyses of the photos.[xxiii] More ambitious student constructed projects can evolve over several years and connect students more closely to their communities as in St. Ignatius, Montana, where high school students have helped to create an on-line community archives.[xxiv]

The power of the digital environment for these kinds of projects comes not merely from their public nature, but from the capabilities of electronic tools for new representations of knowledge in non-linear ways, and through multiple media and multiple voices. Digital tools have the capability to represent complex connections and relationships, as well as make large amounts of information available and manipulable. There is great potential, which we have only begun to understand, in using digital tools for constructionist learning approaches that help students acquire and express the complexity of culture and history knowledge. Student constructionist projects offer a potentially very rich synthesis of resources and expressive capabilities; they combine archival and database resources, with conversational, collaborative, and dialogic tools, in digital contexts characterized by hypertext and other modes for discovering and representing relationships among knowledge objects.

3. What to Avoid? Hazards Along the Electronic Frontiers

These are all appealing goals and there is some encouraging, although still preliminary, experience to suggest that technology can help us achieve them. But it would be foolish, if not dangerous, to suggest that technology is either a panacea for the problems of social studies education or that any of these approaches is easy to implement. Indeed, the most serious danger from the introduction of technology into the classroom is the mistaken assumption that it, alone, can transform education. The single-minded application of technological solutions to teaching will as surely be as much of a disaster as the application of single-minded solutions to agriculture or forest management. As the first generation of scientific foresters learned, any change in a complex environment needs to be thought about *ecologically*.[xxv] New technologically enhanced approaches—whether inquiry-based learning or student constructionist exercises—must be carefully introduced within the context of existing teaching approaches as well as existing courses and assignments. What assignments are already working well? How will a new assignment alter the overall balance of a course? How do new approaches manifest themselves throughout a curriculum or a school?

By asking these questions, we should be also reminding ourselves to use technology only where it makes a clear contribution to classroom learning. Some teaching strategies, for example, work better with traditional materials. A teacher who has his students post rules of historical significance on butcher paper around the classroom may find that their visual presence is stronger on the classroom walls than on the class Web site. More generally, technology is generally better employed to provide a deeper understanding of some pivotal issues through inquiry and constructionist assignments rather than being pressed into service to respond to standards-based pressures for coverage.

By always thinking about whether new technologies respond to the goals with which we began, . we can also be alert to the situations whether technology might operate in the opposite direction from which we intend. Here, it is important to acknowledge that while there are plenty of positive experiences with technology to draw upon, there is also a large body of negative examples that we also need to learn from. The most obvious set of examples can be found in a large body of educational software that promotes passivity rather than the much-promised "interactivity." One of the great advantages of digital media—the ability to incorporate sound and film with text and images—is also one of its greatest problems because of the temptation to turn history into TV commercials in which the media glitz overwhelms sustained contact with difficult ideas. This has been the case with some multi-million dollar multi-media extravaganzas that have been produced that offer multiple interpretations of topics without giving the user any sense of which interpretations are more plausible than others, or without any real level interactivity that encourages active and critical thinking.

Some of these same tendencies were also embodied in the worst of the CD-ROMs that appeared on the market in the early and mid 1990s. In many, the notion of multimedia was a voice reading words that already appeared on the screen. Or, for example, one CD-ROM (that sold for $395) turned out to be a recycled filmstrip—and a twenty-five-year-old one at that.[xxvi] Such uses of digital media are not only going to promote the same deadening memorization of facts that generations of students have complained about but also waste scarce school funds on the products of sleazy educational hucksters.

The pressure of commercial vendors leads to an another related pitfall—the possibility that school systems will invest in equipment, software, and narrowly defined technological training at the expense of funding professional development to use new technology wisely. Computers are expensive, delicate machines that break down often and require recurrent maintenance. The rapid development of the field means that computer labs quickly become outdated. Wiring classrooms for Internet access is expensive and sometimes difficult, particularly in older school buildings. Software can also be costly, and the constant updates required to stay in step with new resources highlights the need for instructional technology staff. Providing effective staff development for teachers throughout the educational system would add significantly to the cost of purchasing hardware. The combined expense of installing, maintaining and supporting the effective use of operative computer labs can be overwhelming. And, as Diane Ravitch rightly points out, "the billions spent on technology represent money not spent on music, art, libraries, maintenance and other essential functions."[xxvii]

Such costs weigh unevenly on different schools, school systems, and communities—another key threat that new technology poses. Under-resourced schools and colleges have a particularly difficult time finding the funds to pay the price required for new technology. While federal, state, and corporate grant programs are helpful, they are not sufficient; and they usually pay only for hardware, not for maintenance or staff development. As a result, the schools and colleges serving poor and working-class communities lag behind in the effective implementation of technology. And their students—disproportionately African American or Latino—are the ones that suffer most. According to the most recent report from the National Center for Education Statistics, 51% of public school classrooms nationwide have Internet access. But for schools with large numbers of poor or minority students, the number drops to less than 40%. This disparity shapes colleges and universities as well. While 80.1% of all students entering elite private colleges report they use computers regularly, only 41.1% percent of students entering historically black colleges report similar usage. In many colleges, students who come from under-resourced school systems will find technology to be one more item to be added to an already-daunting list of educational and social challenges. There is a real—and in many ways a growing—threat that new technology will add to the already immense nationwide stratification of educational opportunity. Indeed, the most recent national report on the "digital divide" indicates that technology use continues to split along lines of both class and race.[xxviii] And the problem is even worse when considered internationally.

Finally, there is the larger danger that educators, parents, and school boards come to see technology as an end in itself rather than a means to achieving better student learning.

Technology can act as a powerful narcotic that lulls us into believing that we are teaching students to think simply by putting machines into classrooms. The hardest intellectual and pedagogical problems—teaching students to judge the quality of information, to deal with conflicting evidence, to develop analytical frameworks—are present in both the print and digital environments.

4. What Next? Toward Student Learning

Not surprisingly, our recommendations for the future grow out of our experience with this new (but by now decade long) history of digital technology in the social studies classroom.

First, we would urge a renewed national commitment to insuring that the benefits of new technology be shared equally. Many others have made the same point, and there is little need for us to belabor it here.

Second (and while we are still tilting at windmills), we would argue that assessment needs to be revised to accurately measure learning in the new media environment. Right now, standards and assessment tend to hinder the integration of technology into teaching. When assessment, as in most states, requires pre-twentieth-century technology (i.e., pen and paper) and is focused on content and factual knowledge, teachers are understandably reluctant to adopt strategies that take advantage of the potential of technology to promote deeper understanding. But if the assessment were designed to reflect deeper understanding of reading, interpreting and arguing processes as well as what students need to know in the twenty-first century—including how to use the Internet and computers to research, analyze, and present information—then the integration of technology into the social studies and other academic curricula would be greatly fostered.

Third, we think that teachers need more tools and supports that will enable them to use electronic resources actively and critically. Teachers value gateway sites because they provide reliable starting points, filtering mechanisms, and sample curricula for using the Web.[xxix] In addition, since many teachers are themselves relative novices in the archives, they need guides to evaluating and analyzing primary source materials. They also need the kinds of software tools that allow their students to collaborate electronically with ease. And they need access to software and hardware that makes student constructionist projects feasible in multiple settings. Such software environments need to remain open and flexible, and not "one-size fits all" templates that presuppose certain teaching styles or approaches.

Fourth, teachers need robust professional development programs that will allow them to retool for the electronic future. The billions of dollars invested in "preparing schools for the twenty-first century" have gone (and continue to go) overwhelmingly to hardware and wiring. Where teachers lack necessary training and support, computer labs frequently wind up gathering dust, or being used as glorified typing labs. We would argue that meaningful progress in this field requires that funding for professional development must be given equal priority with funding for hardware. But it is not simply a matter of the quantity of available faculty development; it is also a question of quality. Typically, professional development in technology focuses narrowly on building technology skills or familiarizing teachers with particular software applications. The most common faculty development structure is a two to four hour workshop led by technology support staff who are skilled in technical issues but relatively distant from the latest thinking about disciplinary content and teaching methodology. Our experience and feedback from our colleagues suggests the importance of developing a different approach.

In particular, we would encourage leaders in the field to create, nurture and support professional development approaches that are deeply rooted in the issues and experiences of everyday classroom practice and build directly on teacher's expertise teaching in non-technological settings, and models ways to adapt their skills to a new context. They need to speak to real classroom needs, helping teachers to find ways to use technology to solve long-standing problems, do their work better, and more effectively reach their goals for their courses and their students. And they must point teachers towards classroom implementation, testing and experimentation with real students in real classroom situations. In addition, professional development needs to involve *a sustained and recursive process.* Instead of one-shot workshops, effective professional development with technology must unfold over time and provide multiple opportunities for teachers to move back and forth between initial training workshops, classroom testing, and reflective seminars where they can articulate and collectively analyze their experiments using new technology resources.

Such approaches will themselves benefit from the effective uses of technology. One of the most exciting things that the Internet has brought to teachers has been the erosion of the isolation that traditionally afflicts the classroom teacher. The teachers with whom we have worked in Crossroads, the New Media Classroom, and the American Memory fellows program have acquired a much broader set of colleagues than was ever possible before. On a regular basis they consult with each other on how to teach a particular subject or to organize a particular assignment. Other teachers have developed mutually supportive relationships with teachers across the country who they have never met but with whom they converse through lists like H-High, H-Teach, the "Talking History" forums sponsored by *History Matters*, or "Highroads" sponsored by Crossroads. In some of these settings, the high school teacher in Kansas City can get advice on the latest developments in women's history from a leading scholar like Gerda Lerner or they can find out about successful assignments from an award-winning high school teacher from Virginia. The often-chaotic information environment of the Web also encourages teachers to forge partnerships with school librarians, who can bring particular skills in information evaluation to the table.

Fifth, given the difficulty of altering entrenched patterns of professional development, it makes sense to focus efforts on pre-service education as well as in-service. Such efforts—as manifest in education curricula and state certification requirements—need to go considerably beyond courses on new media and teaching methods. Future teachers most need discipline-based courses in which technology is integrated into the course content. Such courses can enable teachers to understand the archive-at-a-mouse-click not as some new way to bring the library to the doorstep, but as a fundamental shift in how society handles knowledge, its accessibility, and what one can do with it. Moreover, teachers will never make effective use of the vast archives now accessible to them unless they understand, for example, the nature of historical evidence and argumentation or other disciplinary contexts for using new media.[xxx] More generally, the educating of teachers to use technology effectively must go far beyond simple training in software or techniques for implementation to include an initiation into habits of reflective practice that will allow them to adapt and innovate in new learning environments throughout their careers, even as specific technologies and applications change.

Sixth, we need to acknowledge that we are still at the starting point of the selective appropriation of new technology and that we need serious classroom research into what does and doesn't work. Some of this research needs to come from professional educational researchers. But we also believe that research can be combined with professional development where the teacher becomes the researcher. The approaches that have begun to emerge on the college level under the rubric of the "scholarship of teaching," and are beginning to be explored on the pre-college level as well.

• • •

But whatever approaches are taken we need to return continually to first principles and ask ourselves: what are we trying to accomplish in the classroom? Can technology help to make that possible? One way to keep that mantra in mind is to recall the old joke about a man who works in a factory and leaves there every evening with a wheelbarrow full of straw. Every night as he exits the factory and passes through the gate, the guard looks through the straw, certain that the man is stealing something. At the end of twenty years employment, the man is departing, as always with his wheelbarrow full of straw. The guard turns to the man and says:

> "For twenty years you have been leaving every night with a wheelbarrow full of straw. For twenty years, every night, I look through the straw and find nothing. I know you have been stealing something. This is your last night. For my own curiosity, you have to tell me: what have you been stealing all these years?"

The man replied, "Wheelbarrows." If that joke were taken as an analogy, then technology is the straw. It is merely the prop by which we are getting something more valuable (the wheelbarrow) out the door. And what are the more valuable things we're trying to get out the door? They are, we would argue, the enhancement of learning through interaction and dialogue; an increasingly expansive, inclusive, and socially conscientious approach to the study of history, society, and culture; and the elevation of our standards for what passes as student learning.

ENDNOTES

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[i] Some of the material in this paper was drawn from "Teaching Culture, Learning Culture, and New Media Technologies," by Randy Bass and Bret Eynon, an introductory essay for the volume, "Intentional Media. The Crossroads Conversations on Learning and Technology in the American Culture and History Classroom," *Works & Days* Spring/Fall 1998. The authors are indebted to Bret Eynon, Deputy Director of the American Social History Project/Center for Media and Learning, both for his contributions to the earlier text and, more significantly, to the ideas behind this paper, which are in large ways the product of his collaborations. We also want to thank the following for helpful comments on and suggestions for this paper. Debbie Abilock, Mike Alcoff, Marta Brooks, Donlan, John Elfrank-Dana, Kathy Isaacs, Frances Jacobsoen, Dawn Jaeger, Ron Stoloff, Carl Schulkin, Peter Seixas, Bill Tally, Eileen Walsh, and Sam Wineburg.

[ii] Quotes from 1880 and 1881 *Scientific American* in Steven Lubar, *InfoCulture. The Smithsonian Book of Information Age Inventions* (Boston, 1993), 130, and Claude S Fischer, *America Calling A Social History of the Telephone to 1940* (Berkeley, 1992), 2 (see also pp 1 and 26) Carolyn Marvin, *When Old Technologies Were New Thinking about Electrical Communication in the Late Nineteenth Century* (New York, 1988) and Graham Rayman, "Hello, Utopia Calling?" in *Word* (no date) at http://www.word.com/machine/jacobs/phone/index.html

[iii] Rossetto quoted in David Hudson, *Rewired A Brief and Opinionated Net History* (1997), 7; Al-Jumhuriya in R J Lambrose, "The Abusable Past," *Radical History Review* 70 (1998) 184.

[iv] Robert Lenzner and Stephen S. Johnson, "Seeing Things as They Really Are," *Forbes* (March 10, 1997), available on line at http://www.forbes.com/forbes/97/0310/5905122a.htm; Birkerts in "The Electronic Hive Two Views:" "Refuse It" (Sven Birkerts) and "Embrace It" (Kevin Kelly), *Harper's Magazine* (May 1994) See also Sven Birkerts, *The Gutenberg Elegies The Fate of Reading in an Electronic Age* (1994); Todd Oppenheimer, The Computer Delusion," *Atlantic Monthly* (July 1997).

[v] Philip E. Agre, "Communities and Institutions The Internet and the Structuring of Human Relationships," circulated through Red Rock Eater's News Service, copy available at http://www.egroups.com/group/rre/804.html?

[vi] Readers will note that many of our references here are to the teaching of history and American culture, since those are our own specialties, but we think that our arguments apply broadly to social studies.

[vii] Sam Wineburg, "Making Historical Sense," in Peter Stearns, Sam Wineburg, and Peter Seixas, eds., *History Education in a National and International Context* (forthcoming NYU Press). On the question of factual knowledge, the most influential study of recent years has been Diane Ravitch and Chester Finn Jr., *What Do Our 17-Year-Olds Know? A Report on the First National Assessment of History and Literature* (New York Harper & Row, 1987) There is a large literature debating the work of Ravitch and Finn. See, for example, William Ayers, "What Do 17-Year-Olds Know? A Critique of Recent Research," *Education Digest* 53 (Apr, 1988) 37-39; Dale Whittington, "What Have 17-Year-Olds Known in the Past?" *American Educational Research Journal* 28 (Winter 1991) 759-80; Deborah Meier and Florence Miller, "The Book of Lists," *Nation*, 245 (Jan 9, 1988) 25-27; Terry Teachout, "Why Johnny is Ignorant," *Commentary* (March 1988), 69-71. There have been two more recent studies by the National Assessment of Education Progress (NAEP For brief reports on these, see Michael Mehle, "History Basics Stump U.S Kids, Study Finds," *Bergen Record*, April 3, 1990, A1; Carol Innerst, "History Test Results Aren't Encouraging; US Teens Flop on 'Basic' Quiz," *Washington Times*, November 2, 1995, A2.

[viii] Roy Rosenzweig and David Thelen, The *Presence of the Past Popular Uses of History in American Life* (1998); see also http://chnm.gmu.edu/survey.

[ix] For Crossroads, see http://www.georgetown.edu/crossroads/; for New Media Classroom, which is co-sponsored by American Social History Project/Center for Media & Learning (ASHP/CML) in collaboration with the American Studies Association's Crossroads Project, see http://www.ashp.cuny.edu/index_new.html; for American Memory Fellows, see http://memory.loc.gov/ammem/ndlpedu/amfp/intro.html

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[x] See http://www.nueva.pvt.k12.ca.us/~debbie/library/cur/20c/turn.html

[xi] For WPA life histories, see http://lcweb2.loc.gov/ammem/ndlpedu/lesson97/firsthand/main.html ; for use of free black registers, see http://historymatters.gmu.edu/text/3freeblacks-shulkin.html

[xii] National Center for History in the Schools, *National Standards for United States History Exploring the American Experience* (1994), 29.The new American Association of School Librarians standards for student learning similarly focus on information literacy, on the ability to find, select, analyze, and interpret primary sources See "Information Power The Nine Information Literacy Standards for Student Learning" at http://www.ala.org/aasl/ip_nine.html

[xiii] The Oyez Project, Northwestern University, *U.S Supreme Court Multimedia Database* http://oyez.nwu.edu/; the *U.S. Holocaust Memorial Museum* at http://www.ushmm.org/ *Liberty, Equality, Fraternity Exploring the French Revolution* is being developed by the Center for History and New Media at GMU and the American Social History Project at CUNY and will be available in early 2000 at http://chnm.gmu.edu/revolution. For a discussion of history Web sites, see Mike O'Malley and Roy Rosenzweig, "Brave New World or Blind Alley? American History on the World Wide Web," *Journal of American History* (June 1997), 132-155.

[xiv] Library of Congress, *Inventing Entertainment the Early Motion Pictures and Sound Recordings of the Edison Companies* at http://memory.loc.gov/ammem/edhtml/edhome.html For plans for National Gallery of Recorded Sound, see http://www.h-net.msu.edu/about/press/ngsw.html.

[xv] Ed Ayres, "The Futures of Digital History," unpublished paper delivered at the Organization of American Historians, Toronto, April 1999 (copy in possession of authors).

[xvi] On the "novice in the archive," see Randy Bass, "Engines of Inquiry Teaching, Technology, and Learner-Centered Approaches to Culture and History," in American Studies Crossroads Project, *Engines of Inquiry A Practical Guide for Using Technology in Teaching American Culture* (1997), which can be ordered from http://www.georgetown.edu/crossroads

[xvii] Sam Wineburg, "The Cognitive Representation of Historical Texts," in G. Leinhardt, I. L. Beck, and C.Stanton, eds., *Teaching and Learning in History* (1994), 85. See also Allan Collins, John Seeley Brown, and Ann Holum, "Cognitive Apprenticeship Making Thinking Visible," *American Educator* (Winter 1991), 6-11, 38-46.

[xviii] At the collegiate level, some of the greatest advantages to using electronic interaction is that it increases the amount of time that students are focused on and interacting about the subject. Another advantage is the opportunity for "asynchronous" discussion students can engage in the conversation on their own schedule, rather than only at the time when the instructor and other students are available. These uses are less pertinent at this time for the K-12 context than other benefits of on-line interaction that we describe.

[xix] See http://www.internet-catalyst.org/projects/PCG/postcard.html

[xx] See http://www.fred.net/nhhs/html/newspage.html

[xxi] *Constructivism* implies a theory of learning that emphasizes the active creation of knowledge by the learner, rather than the imparting of information and knowledge by the instructor. *A* second meaning for constructivism, sometimes also called *constructionism*, is the extension of constructivist approaches that stresses the building of knowledge objects, "Constructionism," as defined by Yasmin Kafai and Mitchel Resnick, "suggests that learners are particularly likely to make new ideas when they are actively engaged in making some type of external artifact which they can reflect upon and share with others." Kafai and Resnick, *Constructionism in Practice Designing, Thinking, and Learning in a Digital World* (1996), 1.

[xxii] http://www.fcps.k12.va.us/VirginiaRunES/museum/museum.htm Daniel Sipe Presentation at NMC, New York, July 1997

[xxiii] See http://www.wms-arl.org/amf1/student.htm

[xxiv] See http://206.252.235.34/projects/local.htm For a taxonomy of student constructive projects, with links to school and college-based examples, see http://www.georgetown.edu/crossroads/constructive.html

[xxv] On the problems of scientific forestry, see James Scott, *Thinking Like a State How Certain Schemes to Improve the Human Condition Have Failed* (1998), 11-22.

[xxvi] On history CD-ROMs, see Roy Rosenzweig, "So, What's Next for Clio?" CD-ROM and Historians," *Journal of American History* (March 1995), 1621-1640.

[xxvii] Diane Ravitch, "The Great Technology Mania," Forbes (March 23, 1998), available on line at http://www.forbes.com/forbes/98/0323/6106134a.htm

[xxviii] U.S Department of Education, National Center for Education Statistics , "Internet Access in Public Schools and Classrooms 1994-98," February 1999, available on line at http://nces.ed.gov/pubs99/1999017.html See also National Telecommunications and Information Administration, U.S Department of Commerce, *Falling Through the Net Defining the Digital Divide* (July 1999), available at http://www.ntia.doc.gov/ntiahome/digitaldivide/ and Paul Attewell and Juan Battle, "Home Computers and School Performance," *The Information Society* 15:1 (1999), which finds that students with computers at home have higher test scores even after controlling for family income but that children from high socio-economic (and white) homes show larger educational gains with home computers than do lower SES (and minority) children

[xxix] For two examples of gateways see *American Studies Electronic Crossroads* (http://www.georgetown.edu/crossroads/) and *History Matters The U.S Survey Course on the Web* (http://historymatters.gmu.edu)

[xxx] See Sam Wineburg, "Historical Thinking and Other Unnatural Acts," *Phi Delta Kappan*, 80 (March 1999) 488-99.

- Your Comments
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Forum on Technology in K-12 Education: Envisioning a New Future--Science

By Steven Rakow

This paper explores the realities and possibilities of instructional technology applications in science education. The paper begins with a discussion of the definition of technology. To a science educator, technology refers to the application of science to solve human problems, or, as the International Technology Education Association says, Technology is Human Innovation in Action!" Hence, the term Instructional Technology will be used in this paper to distinguish that domain from the broader view held by science educators

The paper summarizes some of the current impacts of instructional technology as a starting place. Included in this consideration is the rapid growth in availability of the Internet to connect schools and classrooms. But of concern is the continuing disparity between wealthy and poor districts.

Given that reality, the paper discusses two general application of instructional technology in the science classroom, termed "The Global Classroom" and "The Technologically Enhanced Classroom."

The Global Classroom. With the increase in access to the Internet, the science classroom is truly becoming a global classroom. Students have the opportunity to share data with students and scientists from around the world. They can access real-time data. The isolation of the classroom can be a thing of the past.

However, with this vast resource comes the concern that the Internet is becoming unmanageable for most teachers. It is important that mechanisms be established to identify sites that are both accurate in content and age appropriate for students

The Technologically Enhanced Classroom. As new technologies enter the science classroom, new learning opportunities are also present. The use of laboratory interface devices, for example, has opened up an array of laboratory experiences for students that might have previously been limited to college-level courses. Laser videodics, and CD-ROMS provide a wealth of additional resources for the science classroom. Robotics allows the students to see the interface between instructional technologies and the scientific technologies.

In order for technology to improved instruction in the science classroom it is important that professional educators continue to be actively involved in the conceptualization and development of new technologies. It is that perspective of understanding the development of children that is critical to making technologies useful. Furthermore, it is critical that new technologies be aligned with National Science Education Standards so that they are an integral part of the curriculum. Finally, it is important that new technologies support collaboration rather than isolation

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FORUM ON TECHNOLOGY IN K-12 EDUCATION: ENVISIONING A NEW FUTURE

SCIENCE

Steven J. Rakow
Professor, Science Education
Chair of Curriculum and Instruction
University of Houston-Clear Lake
and
Retiring President
National Science Teachers Association

At first glance the classroom seemed to be chaos. Mr. Jackson's fourth graders were spread throughout the classroom, huddled in groups, working on different tasks. Four students were accessing the Internet to download information about different kinds of bridges. Another group, building a model of a suspension bridge, was using a hand-held calculator to predict the weight that their model bridge could hold before collapsing. Another group clustered around a speaker phone firing questions at a mechanical engineer on the other end of the line who was helping them to refine their design while a fourth group was using the on-line encyclopedia to research the history of bridges and bridge building for their background report. The last group was using presentation software to develop a report to give to the class describing their bridge design.

Does this sound like a future scenario? For many schools it is. Yet none of these are technologies that are new or potentially unavailable to our nation's teachers and students.

WHAT IS TECHNOLOGY?

Before we can envision a future for technology in K-12 science education, we need a starting point, and a good starting point is to first define "technology." For a science educator, technology refers to much more than computers, CD-ROMs, and the Internet. These devices, which we will call "instructional technologies," represent the application of technology to the teaching and learning process.

Perhaps the International Technology Education Association best encapsulates the science educator's notion of technology in their logo, "Technology is Human Innovation in Action!" They go on to define technology as having five dimensions:

- Designing, developing, and utilizing technological systems
- Open-ended, problem-based design activities
- Cognitive, manipulative, and affective learning strategies

- Applying technological knowledge and processes to real world experiences using up-to-date resources

- Working individually as well as in a team to solve problems."

In the late 1980s and early 1990s, the American Association for the Advancement of Science embarked upon a landmark project entitled Project 2061. The goal was to reform science education. Part of this process involved identifying what scientifically literate Americans should know about science and how this should effectively be taught. *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993) was the document in which they laid out this scope and sequence of science and to define the connections between and among science, mathematics and technology. They defined technology as:

> "Technology is an overworked term. It once meant knowing how to do things—the practical arts or the study of the practical arts. But it has also come to mean innovations such as pencils, television, aspirin, microscopes, etc., that people use for specific purposes, and it refers to human activities such as agriculture or manufacturing and even to processes such as animal breeding or voting or war that change certain aspects of the world. Further, technology sometimes refers to the industrial and military institutions and know-how. In any other senses, technology has economic, social, ethical, and aesthetic ramifications that depend on where it is used and on people's attitudes toward its use." (page 43)

Similarly, the *National Science Education Standards* (National Research Council, 1996) considers "Science and Technology" to be one of the eight content standards. According to this document (page 106),

> "The science and technology standards … establish connections between the natural and designed worlds and provide students with opportunities to develop decision-making abilities. They are not standards for technology education; rather, these standards emphasize abilities associated with the process of design and fundamental understandings about the enterprise of science and its various linkages with technology."

The National Science Teachers Association document, *Pathways to the Science Standards: Middle School Edition* (Rakow, 1998) describes the progression of understanding of technology envisioned by the *National Science Education Standards*. Students in the elementary grades develop simple design applications that do not distinguish between science and technology. As they move into the middle grades, they begin to distinguish between science and technology in their designs and compare the work of scientists and engineers. Finally, at the high school level, the students are conceptualizing much more complex technological solutions for problems and evaluate the consequences of these solutions in terms of societal implications.

Hence, for the science educator, the term "technology" takes on a much broader context than instructional technologies. Technology encompasses the wide range of endeavors, including identifying appropriate problems for technological design, designing a solution or a product, implementing a proposed design, evaluating completed technological designs or products and communicating the process of technological design. Given that context, the remainder of this paper will focus on "instructional technology ."

WHAT IS THE CURRENT IMPACT OF INSTRUCTIONAL TECHNOLOGIES ON K-12 EDUCATION?

Nicholas Negroponte, Mitchel Resnick, and Justine Cassell (1997) from the Massachusetts Institute of Technology Media Lab argue that "digital technologies can (and should) transform not only how children learn, but also what children learn, and who they learn with." The promise of digital technologies is that children will become more active and independent learners with a broader access to information and resources than ever before. This is certainly compatible with the message of the *National Science Education Standards* which has as its key premises that all students will learn science through an active process using applications to real-world experiences and issues. Thus, instructional technologies are a natural match with science education.

Any discussion of the future impact of instructional technologies should have a grounding in the realities of today's classrooms and communities. According to the National Center for Educational Statistics (1998), by 1998, 89% of schools and 51% of instructional rooms had access to the Internet. This represents a rapid growth from 1994 in which only 35% of the schools and 3% of the classrooms had Internet access. Although there is little difference in school access to the Internet in schools with differing demographic profiles, the issue of classroom access varies greatly. In schools with less that 6% minority enrollment, the percentage of instructional rooms (classroom, computer lab and library/media center) with Internet access was 57%, but in schools with 50 percent or more minorities, that number fell to 37% of instructional rooms. In schools with less that 11% of the students on free or reduced lunch, 62% of the instructional rooms had Internet access, but in schools with 71% of more of students on free or reduced lunch, only 39% of the instructional rooms had access to the Internet. Certainly the Telecommunications Act of 1996 has been a significant factor in this growth by making telecommunications services accessible to schools at a reduced rate[1].

Another measure of technology access is the ratio of students to computers. According to the President's Committee of Advisors on Science and Technology (1997), the optimal ratio is 4 to 5 students per computer. In the Fall of 1998 there were approximately six students for every instructional computer and this number did not vary among schools with differing demographic profiles (National Center for Educational Statistics, 1998). The number of students per instructional computer with Internet access, however, did vary with school demographics. Schools with less that 6 percent minority enrollment or less than 11 percent free and reduced lunch had a ratio of 10 students per Internet accessible computer whereas schools with 50 percent or greater minority enrollment and schools with 71 percent or more free and reduced lunch had a ratio of 17 students per instructional computer with Internet access.

These data illustrate that there has been an incredible growth in Internet access to schools and classrooms and growth in the student use of computers and the Internet. Given this trend, it is not unreasonable to project that in the near future there will be virtually universal access to the Internet in U.S. public schools. One caution, however, is the inequities in access between low and high minority enrollment schools and between high and low income schools. For instructional technologies to play a role in meeting the goal of science education for all students, these inequities must be eliminated.

WHAT IS THE POTENTIAL IMPACT OF INSTRUCTIONAL TECHNOLOGIES ON K-12 SCIENCE?

The classroom scenario that opened this paper illustrated two general types of applications of technology—those technologies that serve to provide students with access to resources beyond the walls of their classroom and those technologies that extend human capabilities. The next section will discuss this two general applications under the headings "The Global Classroom" and "The Technologically Enhanced Classroom."

The Global Classroom. The Internet has the capability to bring the world into the classroom and transport students to places undreamed of. As the previous discussion has shown, it is not an impossible dream. Access to the Internet is growing at an incredible rate with the national goal of every classroom being connected by the year 2000.

The Internet provides students with a vast array of resources, including original research documents, reference materials, and databases. Students can get help with homework, communicate with others from around the world, download satellite images, or develop their own web page, all from their classroom (or home) computer.

As vast and wonderful a resource as the Internet is, that very vastness can be a problem. As reported in *Science* in July 1999 (page 295), there are about 3 million servers hosting 800 accessible web pages. Unfortunately, the eleven most commonly used search engines are combined only able to access about 42% of the web and for the individual search engines, the coverage ranges from 16% to 2.2%.

Certainly schools are making strides in monitoring and controlling student access to web sites that are objectionable. Less progress has been made in monitoring the accuracy and age appropriateness of web sites. Unlike print materials, which generally go through some degree of peer review and whose availability can more easily be controlled, the world wide web is virtually open to anyone with a computer, a modem and the access to a server. How can teachers make effective use of the array of information available on the Internet that seems to be expanding at an exponential rate? How can teachers monitor the accuracy and age appropriateness of the web sites that their students are accessing?

These were questions that troubled the National Science Teachers Association (NSTA). In addition, teachers and textbook publishers bemoaned the fact that, with the rapid advances in science, textbooks were out of date as soon as they left the presses. Thus was born *sci*LINKS[2], an innovative project that links textbooks and the Internet. NSTA places *sci*LINKS symbols into textbooks at key topic areas. By keying in a code number, students, teachers or parents can access a relevant, age appropriate web site that has been selected by a panel of science educators. Although the information in the textbook may be static, *sci*LINKS has the ability to continually update the web site to reflect new information. According to NSTA Executive Director, Gerry Wheeler, "*sci*LINKS has the power to make the ever-growing Internet a manageable, useful tool for the teacher. It shortcuts the path to the teacher and to the learner and provides easy access to the latest information and technology. In fact, when researchers recently found liquid water in a meteorite that fell on Texas, we had information about it in *sci*LINKS the next day." (NSTA, 1999)

The Internet provides the opportunity for students to collaborate across distances. That collaboration can be with scientists, community members, parents, or with other students. One of the pioneers in this was TERC in Cambridge, Massachusetts and their collaboration with the National Geographic Society in developing the KidsNetwork[3] which offers elementary and middle grade students an opportunity to study real-world issues. Research teams of students, representing geographically diverse areas, collect data and share information with each other on the Internet. Participating scientists review the data and help students make interpretations.

Another exciting collaborative project is the GLOBE (Global Learning and Observation to Benefit the Environment) program[4]. GLOBE currently involves over 7,000 schools in more than 80 countries. Students make environmental observations near their schools and report those data through the Internet. Scientists use the data collected for their own research and share their findings with the students.

Negroponte and colleagues (1997) emphasize the value of global collaboration in creating a learning revolution. "Global connectedness can enable new 'knowledge-building communities' in which children (and adults) around the globe collaborate on projects and learn from one another."

The global classroom also opens doors to other student opportunities including virtual field trips, access to informal science centers and virtual science fairs.

Imagine traveling to the bottom of the Atlantic in search of the wreck of the RMS Titanic. The JASON Project[5], under the leadership of explorer and oceanographer Dr. Robert Ballard, has been a pioneer in engaging students in virtual field trips. This year students will be traveling from NOAA's Aquarius Underwater Laboratory in the Florida Keys to NASA's International Space Station. Another web site, The Virtual Field Trip Site[6] is dedicated to providing teachers with access to information and pictures from areas and events that they might not be able to access, such as deserts, hurricanes, oceans, salt marshes, tornadoes, and volcanoes.

Informal science centers[7] (such as zoos, museums, nature centers, and aquariums) provide a wealth of resources to support the science classroom. However, in the past, access has been limited because of travel expenses or time limitations. The Internet lets students learn about the work of Benjamin Franklin at the Franklin Institute's[8] site in Philadelphia or participate in science experiments online from the Exploratorium[9] in San Francisco.

Virtual science fairs allow students to communicate their results to a world-wide audience. Negroponte and colleagues (1997) addressed the importance of students being able to express themselves directly. "New media will enable children to relate their own stories and ideas—and relate them to a much broader and more diverse audience—rather than having adults do the talking for them." The Cyber-Fair[10] sponsored by Mankato, MN Schools allows students in grades 3 through 6 to share their projects on the Internet. Some other virtual science fairs include: Brentwood School's (Los Angeles, CA) 1997 Virtual Science Fair[11] in which projects competing in the school-wide science fair had no printed reports or display; and CyberSpace Middle School[12], sponsored by Florida State University Supercomputer Computations Research Institute.

The Future of the Global Classroom. Given the pervasiveness of internet access currently available in the schools and projected into the near future, it is hard to imagine that the global classroom won't have a profound influence on science teaching and learning. Whether keeping up to date with the very latest developments, accessing real-time data, collaborating with others across the world, participating in experiences in other parts of the world, or communicating with a world-wide audience, the Internet provides the opportunity to bring the world into the classroom and the students into the world. In Learning with Technology (Dede, 1998) the 1998 Year Book of the Association for Supervision and Curriculum Development (ASCD), Kozma and Schank (1998) present a scenario of the connected classroom of the 21st century. They conclude:

> "Connections between school and work will allow students to learn in the context of real-life problems and will allow teachers to draw on the resources of other teachers, a range of professional development providers, and technical and business experts. Connections among schools, homes, and the rest of the community will enable students to relate what is happening in the world outside to what is happening in school, will allow teachers to coordinate formal education with informal learning, and will allow the community to reintegrate education into daily life." (page 5)

The Technologically Enhanced Classroom. In the early days of technology (10 to 15 years ago), there was much debate that technology would replace the teacher. This debate seems to have quieted as new technologies have demonstrated their ability to provide teachers with the time and opportunity to do what teachers do best -- provide human interaction. As Robert Tinker writes (1997), "There is no 'teacher proof' technology that can replace the thoughtful attention and educational guidance provided by an experienced teacher."

Technologies have provided incredible resources for teachers. The CD-ROM allows a teacher to have an entire encyclopedia or the latest census data in the classroom accessible at the click of a mouse. Laser videodiscs can store tens of thousands of images on a disk the size of an LP album or provide motion sequences that can be accessed by frame number. The advent of DVD technologies further expands the access of teachers to quality video resources at a reasonable price.

Robotics provides an opportunity for students to combine technology and science in a real-world application. With the availability of materials such as the LEGOdacto RoboLab[13], elementary school children can design and build robots. The FIRST (For Inspiration and Recognition of Science and Technology) Robotics Competition[14] provides an opportunity for teams of high school students to work with researchers in the design and construction of a robot. The teams compete in a task to test their robot design.

Laboratory interface devices extend the capability of the laboratory by making the computer another piece of laboratory equipment. Increasingly, new laboratories are being designed to fully integrate computers into the physical setting of the lab. The early pioneers of laboratory interface devices included light and temperature probes. Today's microcomputer-based laboratories (MBLs) provide a wide range of probes including, pressure, EKG, alpha waves, heart monitors, conductivity, sound, and motion detectors, just to name a few. These probes, along with the supporting software, allow students to collect, display, and analyze vast quantities of data over time periods ranging from seconds to days.

The Concord Consortium[15] is engaged in an innovative project, Science Learning in Context[16], to develop hardware, software, and curriculum material that use portable, networked, hand-held computers in student field projects. It is expected that these devices will allow students to keep digital journals in the field, to collect field data and consolidate those data with other students, as well as to develop models related to the data. According to Concord Consortium (1997), "using this approach, the researchers expect student inquiry to be more efficient, students investigations will be more expert, the resulting knowledge will be less inert, and many new topics will be amenable to student investigation."

Other advances provide software applications which allow students the opportunity to simulate and model real world events, such as Model-It (Krajcik, Soloway, Blumenfeld, and Marx, 1998) or to explore fundamental concepts in science such as genetics with GenScope[17]. These are just two examples of what is a large number of outstanding computer applications to support science teaching and learning.

The Future of the Technologically Enhanced Classroom? The future of the technologically enhanced classroom must be guided by two principles: access and quality. Access must keep in mind the kinds of hardware available to teachers. Programs that require wide band width or extensive memory may not be practical with the hardware available in schools. Hardware which is only affordable by wealthy schools will further exacerbate the inequities between low and high income schools. Future technologies need to support the premise of science for all students. Additionally, future technologies must be of a high quality. Technology should not be used for technology's sake. The appropriate role for technology is to promote learning in ways that could not happen or could not happen as efficiently without the technology. Teachers play an important role in demanding that suppliers of technology provide materials that are accurate in content and pedagogically sound in design.

How will technology support teachers? Technology will help teachers to do what they do best—meet the human needs of learners. Technology will reduce isolation by providing teachers opportunities to collaborate with colleagues around the world. Already the internet is a treasure house of lesson plans and instructional materials. Technology will also allow teachers to meet the needs of diverse learners. Currently most teachers have from 20 to 30 students in their class, all having different personalities, learning styles, capabilities, interests and motivations. The individualization available from technology, and the ability to manage diverse learners working on different projects and at various rates is one of the great promises of instructional technology. Technology will also allow teachers to communicate more effectively with parents. With the increase in home computers, parents can truly become a part of their children's learning through collaborative learning, access to information about their students projects and assignments, and through frequent email communications with teachers. By making parents and the home partners in learning, the effective learning time is virtually doubled.

It is important that professional educators continue to be actively involved in the conceptualization and development of new technologies for the science classroom. It is that perspective of understanding the development of children that is critical to making technologies useful. Furthermore, it is important that new technologies be aligned with the principles of the National Science Education Standards so that they are an integral part of the curriculum. Finally, it is important that new technologies support collaboration rather than isolation.

The sciences are a natural place for the integration of instructional technologies to improve teaching and learning. These technologies have the capability to potential for expanding the resources of the science classroom beyond imagination. Will we see the day in which instructional technologies are as invaluable to the science teacher as the beaker, balance, and bunsen burner are today? I believe the answer is "YES".

ENDNOTES

[1] For more information about the Telecommunications Act and the E-rate program see: http://www.sl.universalservice.org

[2] For more information about *sci*LINKS, see: http://www.nsta.org.scilinks

[3] For more information about KidsNetwork, see: http://www.terc.edu/byterc/ngs.html

[4] For more information about the GLOBE Program, see: http://globe.fsl.noaa.gov

[5] For more information about the JASON Project, see: http://www.jasonproject.org

[6] For more information about the Virtual Field Trip Site, see: http://www. Field-guide.com

[7] An excellent compilation of hands-on science centers from around the world is available at http://www.cs.cmu.edu/afs/cs/usr/mwm/www/sci.html.

[8] For more information about the Franklin Institute, see: http://sln.fi.edu

[9] For more information about the Exploratorium, see: http://www.exploratorium.edu

[10] For more information about the CyberFair, see: http://www.isd77.k12.mn.us/resources/cf/SciProjIntro.html

[11] For more information about Brentwood School's Virtual Science Fair, see: http://www.csun.edu/~lg48405/virtual/virtual_science_fair.html

[12] For more information about CyberSpace Middle School see: http://www.scri.fsu.edu/~dennisl/CMS/sf/sf.html

[13] For more information about RoboLab, see: http://www.lego.dk/dacta/robolab/defaultjava.htm

[14] For more information about FIRST Robotics Competition, see: http://www.usfirst.org/

[15] For more information about the Concord Consortium, see: http://www.concord.org/

[16] For more information about Science Learning in Context, see: http://slic.concord.org/

[17] For more information about GenScope, see http://genscope.concord.org/.

NOTE: An excellent review of research is found in Berger, C. F, Lu, C. R., Belzer, S. J. & Voss, B. E. (1994). Research on the uses of technology in science education. In D. L. Gabel (Ed.), Handbook of research on science teaching and learning, (pp. 466-490). New York: MacMillan.

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- Forum on Technology in Education
- Emerging Priorities
- '96 ET Plan

Technology Meets Math Education: Envisioning A Practical Future

By Andee Rubin

Any discussion of the future role of technology in mathematics education must integrate enthusiastic vision with careful realism, as the recent past has demonstrated that there is significant potential, but it is often not realized. These considerations *must* be carried out in light of the goals we hold for students' mathematical knowledge and expertise – a wide-ranging mathematical literacy, mathematical habits of mind, an appreciation of and interest in mathematical thinking, an informed view of computation tools. These goals are best served by *the creation of communities of learners in which students are actively engaged in the process of mathematical sense-making*

Several technological developments have great potential to further this goal, e.g. systems for visualizing dynamic connections among mathematical objects, tools for exploring complexity, resource-rich communities on the Web, the ubiquity of basic mathematical tools, and increased opportunities for design and construction. However, there are also critical resources necessary for this potential to be realized in students' educational lives, many of which are not at present available, i.e. resources for appropriate software development, curriculum integration and professional development.

This paper insists that, rather than looking at math education from the perspective of the computer, we must look at computers from the perspective of mathematics education. The primary tenet of this paper is that the role of technology in math education must be in service of goals we hold for student's mathematical knowledge and expertise (based on the NCTM Standards):

- Developing students' "mathematical literacy" that goes far beyond arithmetic computation
- Supporting students' mathematical "habits of mind," e.g. ability to engage in mathematical proof and argument as a basis for logical thought and discussion;
- Preparing students for the judicious and effective use of

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computational tools and technologies;

- Nurturing a positive attitude toward and curiosity about mathematics and mathematical thinking that can serve as the basis of lifelong learning
- Empowering students with the realization that mathematical knowledge does not come predigested from teachers and books, but is a product of their own thought and exploration

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Page last updated on 04/7/00 (cdd)

TECHNOLOGY MEETS MATH EDUCATION: ENVISIONING A PRACTICAL FUTURE
FORUM ON THE FUTURE OF TECHNOLOGY IN EDUCATION

Andee Rubin
TERC

CAMBRIDGE, MA

It is the presupposition of this workshop that computers are here to stay—both inside schools and out—and that significant changes in the way we teach and learn will result from their presence. Far be it for me to question that assumption. But in the midst of the exhilaration of being visionary, I want to temper our expectations with a practical view of where schools and classrooms are now and how much they might change in the next decade. I'm certainly not a Luddite and my intent is not to throw cold water on our flights of fancy, but I firmly believe that simultaneously considering both the vast potential of technology and the current realities of schools can lead us to creative solutions to problems we might not otherwise have considered. In this situation, practicality and therefore necessity, may indeed be the mother of invention.

The pairing of mathematics and technology has a long history; for many years a knowledge of mathematics was considered a prerequisite for becoming a programmer and the use of computers was thus available primarily to a small group of mathematically-inclined enthusiasts. Even now, when many people use computers for writing and communication, math-related programs occupy one third of a recent catalogue of educational software (Sunburst, 1999)—much more than any other topic. But this association may have led us down the wrong path, where we've seen computers primarily as machines for calculating and, educationally, for presenting students with exercises in calculation.

This paper insists that, rather than looking at math education from the perspective of the computer, we must look at computers from the perspective of mathematics education. The primary tenet of this paper is that the role of technology in math education must be in service of goals we hold for student's mathematical knowledge and expertise. Of course, technology may dramatically change those goals as well (which could get us in a serious infinite loop), but it is still the aims of mathematics education to which we must return. Broadly speaking, I take these goals to be (based on the NCTM Standards):

- eveloping students' "mathematical literacy" that goes far beyond arithmetic computation—e.g. a thorough knowledge of our number system that underlies computation and estimation, a facility with data that supports the critical analysis of statistical information with which we are bombarded, a comfort with geometric analyses of space, both two and three dimensional, an understanding of what different representations of mathematical quantities—such as graphs—mean and how they relate;

- Supporting students' mathematical "habits of mind," e.g. ability to engage in mathematical proof and argument as a basis for logical thought and discussion;
- Preparing students for the judicious and effective use of computational tools and technologies;
- Nurturing a positive attitude toward and curiosity about mathematics and mathematical thinking that can serve as the basis of lifelong learning;
- Empowering students with the realization that mathematical knowledge (not to mention much else that we learn in school) does not come predigested from teachers and books, but is a product of their own thought and exploration.

These goals take us far beyond the arithmetic that often occupies the majority of elementary school mathematics education and beyond, as well, the formulaic approaches to algebra ("solve this polynomial") and geometry ("prove this theorem") with which many of us are familiar. These goals are best served by *the creation of communities of learners in which students are actively engaged in the process of mathematical sense-making*. In this paper, the promise of technologies will be measured against this vision.

In this context, we can see that the present and future roles of technology in math education are both powerful and problematic; we need to paint a picture that takes advantage of the potential of technology without falling into the technology = computation trap. There are indeed many significant opportunities that go far beyond this impoverished image and I will describe several below. But it is important to note before jumping into descriptions of several compelling uses of technology in math education (says the realist), that the existence of these opportunities does not guarantee that they will be used effectively—or at all. The effects of technology on education and on society in general are emphatically sociotechnical (Bruce, 1999), that is, the technology has an effect only through people's uses and attitudes, in this case, in particular, through pedagogical philosophy. Technology in a vacuum is just that—technology in a vacuum. We will need to figure out how to create the context that will allow this potential to be realized.

The seeds of most of the potential future uses of technology in math education are present in today's possibilities, although we are just beginning to learn how to take advantage of them. In the following sections, I will discuss several categories of technology use, noting the present situation and future possibilities. The structure of the rest of this paper will be:

1. Descriptions of five powerful uses of technology in math education, present and future;
2. A consideration of the factors that are necessary to fulfill this potential;
3. Some concerns about the integration of technology into math education;
4. A brief closing restatement of the dilemma

POWERFUL USES OF TECHNOLOGY IN MATH EDUCATION, PRESENT AND FUTURE

As a way of organizing the ways in which technology may have substantial and significant effects on mathematics education, I have chosen five types of opportunities afforded by computers, calculators, the Internet/Web, and associated input and output devices. In each case, I will give examples of present uses, note how they support the goals identified and project how uses of this technology might grow in the near future.

DYNAMIC CONNECTIONS

Mathematics is most often thought of as an "abstract" topic, populated by symbols and invisible concepts. For many students, this lack of a visual representation makes it difficult to make connections between a mathematical expression and the situation to which it refers. Technology can help here; computers, in spite of their early image as calculating machines, are decidedly visual and provide a medium in which visual representations can be made dynamic. Students do not have to be stuck with a description in words and symbols OR with a diagram in a book that that can't be examined or explored. Here are two examples of the difference technology can make.

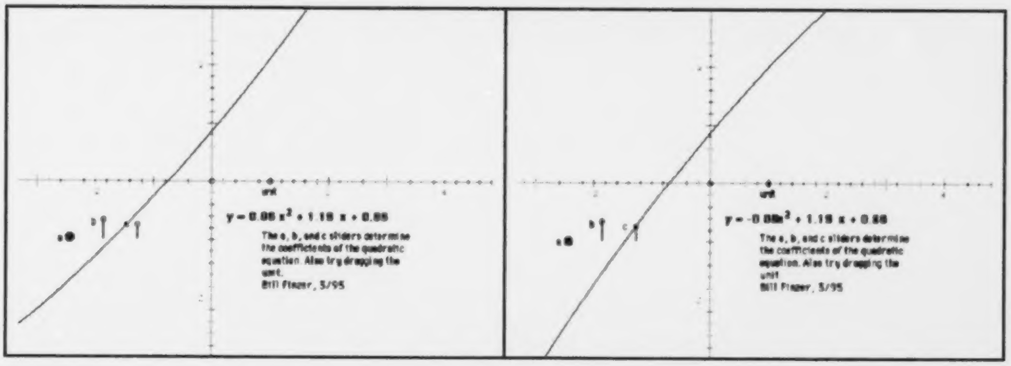
Most students' notions of geometry are, at worst, of two-column proofs that follow a series of arcane rules, illustrated by one or two static line drawings. Many students who enjoy and succeed in geometry are able to supplement these pictures with some sense of motion, e.g.: if this corner of the square moves here, that angle will grow twice as big. The computer allows everyone to visualize these changes. Several pieces of "dynamic geometry" software have dramatically changed possibilities for geometric exploration. These tools go a long way toward turning mathematics into an experimental science—much closer to the way mathematicians experience mathematics than students usually do.

Figures 1a and b show two views of a dynamic diagram from the Geometer's Sketchpad that allows a student to explore quadratic equations (containing the square of one variable) and the curves that they define. The power of this diagram lies in the fact that the student can change the curve by moving any of the three sliders on the lower left to change the value of a, b, and c. As the sliders are moved, both the equation and the graph change at the same time, so the relationship between them is visually apparent. It is precisely this dynamic linking that makes this software powerful. There are many explorations possible using this particular diagram; here is one simple one. Figure 1a shows a parabola whose first coefficient is .06. Note that the curve is almost straight. Figure 1b is a similar parabola whose first coefficient is -.06. This curve is also almost straight, but curves in the opposite direction. The student can move the slider back and forth between these two (and beyond), watching how the curvature changes—and what happens when the coefficient becomes 0—the curve becomes a straight line! To most students, parabolas and straight lines aren't related; after all, one curves and the other doesn't—but this dynamic diagram shows that a straight line is just a parabola with a 0 coefficient.

Not only can computers draw graphs and other mathematical objects and allow students to "play" with them, they can relate them to images in the "real" world. One way these connections can be made is with digital cameras and videocameras; no longer are the pictures we take static objects, but as digital objects they take on a new life that enables them to be closely linked with mathematical representations.

FIGURE 1a and b

Dynamic Geometry Diagrams To Investigate The Relationship Between Parabolas and Straight Lines (Among Other Things)


unit
y = 0.08 x² + 1.18 x + 0.88
The a, b, and c sliders determine the coefficients of the quadratic equation. Also try dragging the unit.
Bill Finzer, 5/95
a
b
c
unit
y = -0.08x² + 1.18 x + 0.88
The a, b, and c sliders determine the coefficients of the quadratic equation. Also try dragging the unit
Bill Finzer, 5/95
a
b
c

One such piece of software is CamMotion (Rubin and Boyd, 1997). CamMotion (a play on Camera and Motion) provides tools to analyze motion as it is captured on a video camera and to create the corresponding graphs of changes in position or speed over time. First, the video is digitized, so that it can be displayed on and controlled by the computer. Then, the student chooses an object to track (e.g. someone's hand) and clicks on it in each frame as the computer plays the video one frame at a time. The data thus gathered can be seen as a graph; speed can be calculated from the distance between adjacent data points and concepts such as acceleration and deceleration can be explored. But perhaps the most important aspect of this software is that the video and the graph are linked, that is, when the student points with the mouse to a point on the graph, the corresponding frame of the video is displayed. Similarly, when the student plays the video, the corresponding points on the graph are highlighted. So the link between the "real world" and its mathematical representation is made visible in a way that is quite striking.

Figure 2 shows an example of CamMotion being used to analyze the motion of a girl doing a cartwheel. The student has clicked on the position of the girl's left and right hands for each frame of the video, than made this graph by displaying the height of her left hand and the height of her right hand on the same graph. You can see that each hand follows a similar path going up and down, with one hand ahead of the other. The displayed video frame corresponds to the highlighted part of the graph; both of her hands are at about the same height, midway between the lowest (floor) and highest points they reach. It is also possible to see how quickly her hands are moving from this graph. When is her hand moving most quickly? Most slowly? How could you tell from this graph?

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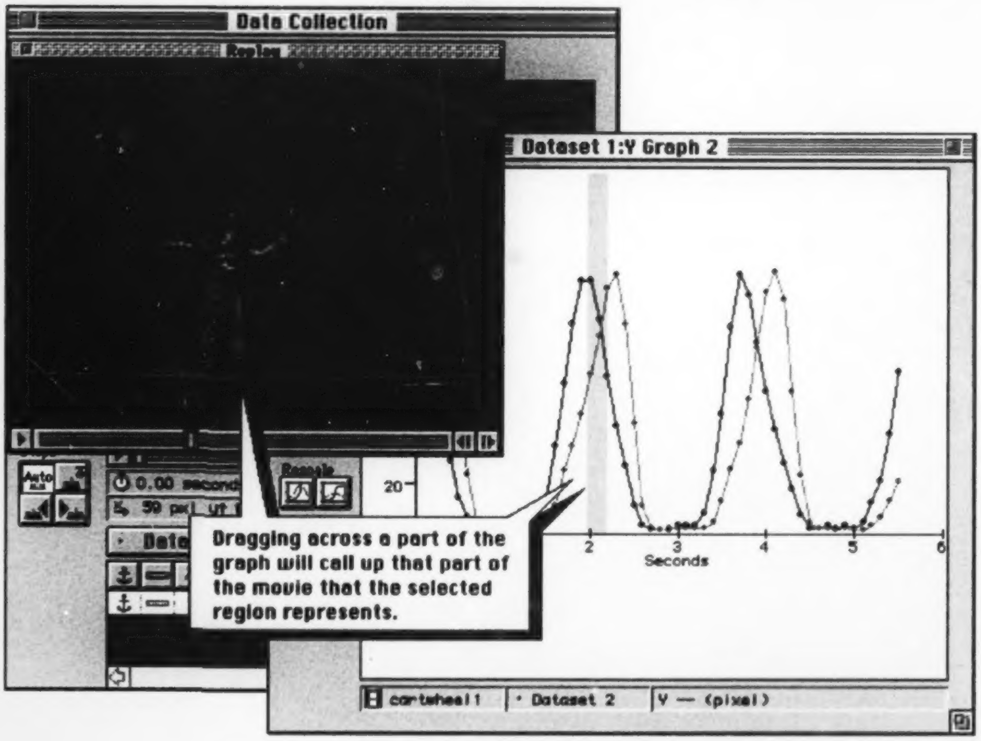
FIGURE 2

A Cammotion Graph of The Motion of a Girl's Hands Doing a Cartwheel



Dragging across a part of the graph will call up that part of the movie that the selected region represents.

Embracing a student's real world like this is especially important when we consider technology's place in math education, because the general effect of computers is to separate students' concrete experiences from their digital representations. Being able to capture students' physical experience is more than just a new "input device;" it allows us to turn some of our mathematics pedagogy on its head. As just one example, imagine if the student's task is to move in a way that matches a particular graph, which, in turn, may have come from another video—we might call this life imitating math imitating life.

As digital devices make it increasingly simple to capture representations of the analog world on the computer, there will be more opportunities to treat the world as a grand data base, whose secrets and rules are waiting to be discovered. These systems provide a more "intimate" connection to the mathematics that can counteract the general effect of computers to separate students' concrete experiences from their digital representation, In addition, they create an environment in which mathematics is an experimental science, in which trying things out and noting what happens is an acceptable—and even preferable—approach. Having shared mathematical representations—

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displayed on a screen that is visible by several students at a time—also supports collaboration, since it provides objects to refer to, talk about, and investigate and goes a long time toward creating a mathematical community.

SOPHISTICATED TOOLS

Many authors have noted the growing importance of numeracy in our lives; few jobs are immune from a need for mathematical sense-making. As a result, many workplaces now provide workers with an integrated tool set (spreadsheet, calculator, graphing calculator, graphing/data analysis tools) and expect that they will have the expertise to use them effectively. Part of the responsibility of math education is to "keep up" with these developments in order to prepare students for the work world. Having such a set of tools widely available to students also has the potential to significantly change the curriculum—to give students access to mathematical topics and insights by removing computational barriers to inquiry.

This is an area of some controversy; many people who grew up mastering pencil-and-paper algorithms fear that if students use calculators they will never learn the basics of computation and will be lost without this tool. In fact, in many ways, the opposite is true: knowing how to use a calculator appropriately requires the student to know which numbers to enter, what operations to carry out and how to interpret the answer—all more important and often more demanding than doing the calculation itself. There is plenty of evidence that the appropriate use of calculators can improve students' mathematical achievement, as well as lead to more positive attitudes toward mathematics. In addition, calculators can add significant richness to students' mathematical experiences. Here are some examples:

The Range Game, developed by Grayson Wheatley, asks students to start with a number (say 37) and, using a calculator, find numbers that when multiplied by it give a number in the range from 500 to 600. In the conversation reported by him, students talk about their estimates, their results, whether they "have them all," and the largest and smallest numbers that would work (which leads to a discussion of decimals and limits.) This kind of conversation, which exercises students' number sense and even leads them into unfamiliar mathematical territory (e.g. limits), would be impossible if calculators were not available.

Graphing calculators have been more consistently praised as enhancing mathematics education. The ease with which they can produce complete pictures for a variety of functions means that students can graph functions, zoom in for greater detail, zoom out to see the function as X increases or decreases and compare graphs of one function with those of others. Simple models—e.g. of population growth—can be built and run on these calculators. In essence, much of the power of programs that a few years ago ran on microcomputers has been captured on personal, portable, affordable technology. Palm Pilots are the latest example of these personal aids; one of the most exciting uses of these hand-held computers is as a data collection device that can go where the student goes, rather than being stuck in a classroom.

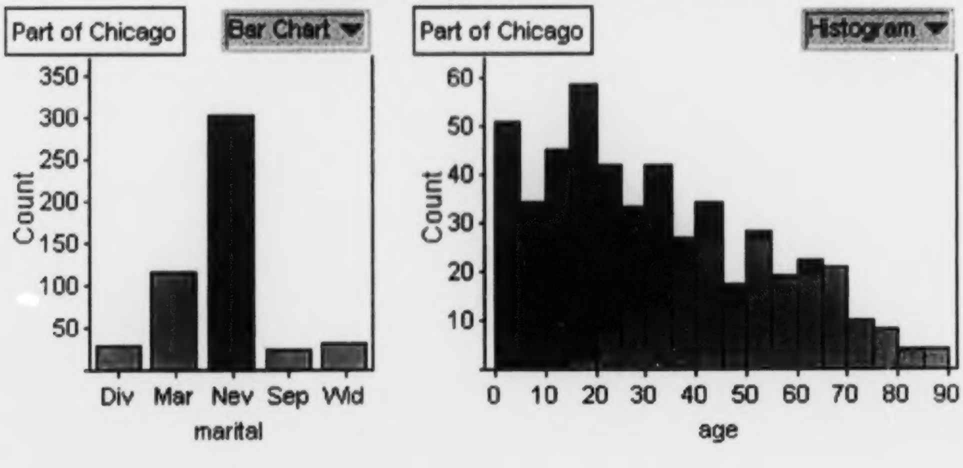
The use of calculators makes possible significant changes in the mathematics curriculum. While it is still important for students to understand computation and be fluent in carrying out problems of reasonable size, there is no reason for students to spend time dividing 5-digit numbers, adding long columns of numbers or finding square roots. The emphasis can instead be on problem-solving and developing number sense. Graphing calculators call into question the emphasis on algebraic symbol manipulation; many of the skills students learn symbolically (e.g. factoring complex polynomials to figure out the roots) are more effectively taught by working with the graphs of the functions.

In addition to calculators, other tools have the potential to change the math curriculum. Sophisticated data analysis tools, for example, expand what students can learn about statistical reasoning. The newest tools do more than produce fancy graphs; they facilitate the discovery of patterns through exploratory data analysis. These tools are well-suited for complex data bases with many variables and employ new kinds of graphs, many of which are interactive in ways similar to the dynamic geometry software described above. Many of these tools are actually used by statisticians, and several are designed with educational purposes as well. One such tool is Fathom, a sophisticated tool that provides students with many ways to look at—and therefore understand—complex data bases. Here is a relatively simple example, illustrated in Figure 3:

The data set is of a large number of people in Chicago—two of the variables are age and marital status. To see how old people are in each marital category (divorced, married, never married, separated, widowed), we can select that bar in the left hand bar graph and all the matching people are highlighted in the histogram graph on the right; this graph shows that most (but not all) of the people who have never been married are young. We can investigate related questions by choosing other bars in the bar graph (e.g. how old are the people who are divorced?) or by choosing one or more of the bars in the histogram and seeing how people in that age group are distributed among the marital categories. (e.g. What portion of people in the 50–60 age category are divorced?) In general, Fathom makes it easy to do intelligent data analysis: the student can research a question with a few simple commands and the resulting graphs will provide at least a partial answer to the question—and inevitably pose additional ones.

FIGURE 3

Fathom Graphs Exploring the Relationship Between Age and Marital Status



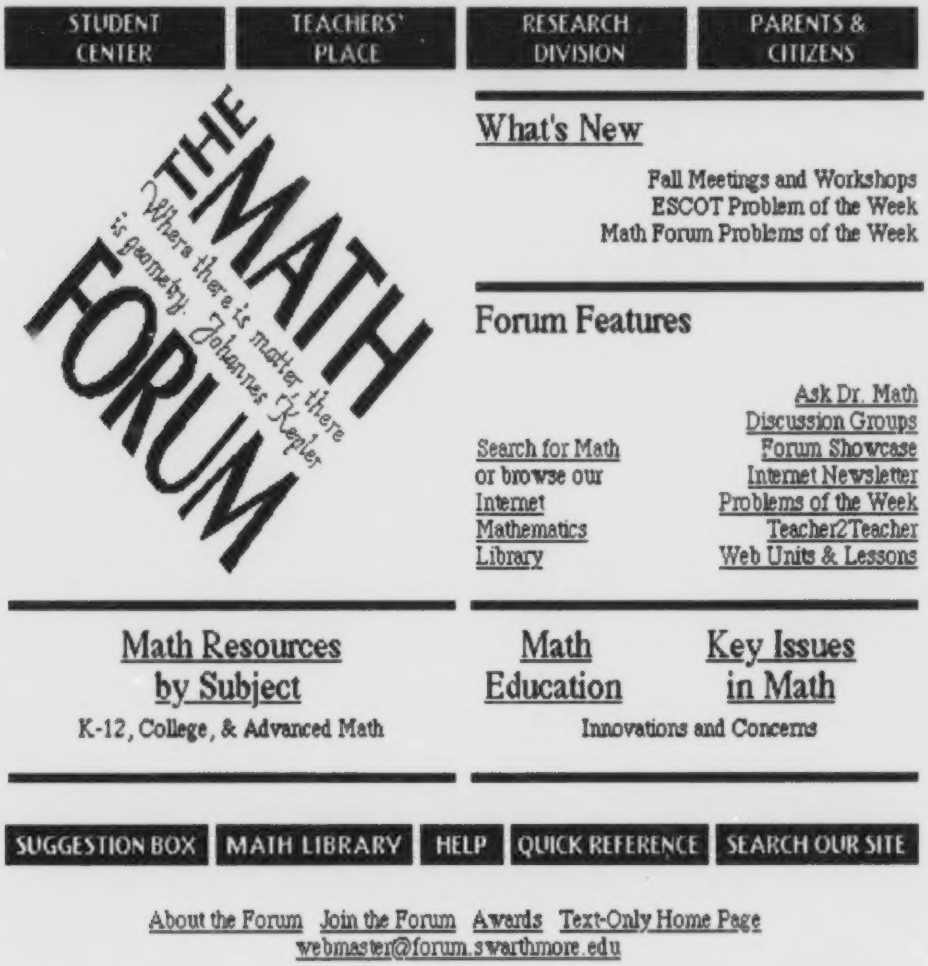
The value of such tools is that they create a boardwalk over the computational swamp, allowing students to see patterns they would never glimpse if they had to do the calculations or even draw the graphs themselves. In this way, exploratory data analysis software (and other visualization techniques) play a similar role to calculators and graphing calculators in emphasizing the meaning in mathematical objects and the beauty of the patterns they exhibit.

RESOURCE-RICH MATHEMATICAL COMMUNITIES

More than any other recent development, the Web has changed the public's view of technology; while few people had even heard of the Web five years ago, it is now almost impossible to watch a television ad that does not mention a Web site. The amount of information available on the Web continues to expand exponentially as more and more diverse organizations—profit-making, non-profit, large, composed of one person—are getting into the act.

This extraordinary growth has led to several developments that have important implications for mathematics education:

Resource sites. The best known of these is the Math Forum (www.mathforum.org), whose home page is shown as Figure 4 on next page.


STUDENT CENTER
TEACHERS' PLACE
RESEARCH DIVISION
PARENTS & CITIZENS
THE MATH FORUM
Where there is matter, there is geometry. Johannes Kepler

What's New

Fall Meetings and Workshops
ESCOT Problem of the Week
Math Forum Problems of the Week

Forum Features

Search for Math or browse our Internet Mathematics Library

Ask Dr. Math
Discussion Groups
Forum Showcase
Internet Newsletter
Problems of the Week
Teacher2Teacher
Web Units & Lessons

Math Resources by Subject
K-12, College, & Advanced Math

Math Education

Key Issues in Math

Innovations and Concerns

SUGGESTION BOX
MATH LIBRARY
HELP
QUICK REFERENCE
SEARCH OUR SITE

About the Forum Join the Forum Awards Text-Only Home Page
webmaster@forum.swarthmore.edu

Figure 4
Math Forum Home Page

The Math Forum site includes a large list of (screened for quality) resources for K through college math teaching, including interactive activities; recommendations of software; examples of classroom activities and links to related discussion groups; a conversation space for teachers (Teacher2Teacher); an extensive Internet Math Library, which contains even more resources than the resource list; an Ask Dr. Math feature, in which an expert answers students' questions (the most recent topic is rounding); Problems of the Week at a variety of levels of difficulty; discussion groups on topics such as discrete math and a multi-lingual discussion on the history of mathematics; A Forum Showcase that highlights recently added sites, e.g. the following:

> Exploring Data—Pages for finding and displaying data sets, designed to support workshops on statistics given by the Math Forum for the Urban Systemic Initiative (Philadelphia and San Die go). Included are: links by level to relevant statistics Standards (NCTM, California, Philadelphia); lesson plans for collecting, analyzing, and/or displaying data; sources of data sets, general information, courses, and statistics software on the Web; and an "Oceans of Data" page with a data set (diving records) to download, instructions for making ClarisWorks graphs, suggested questions for discussion, and related 'ocean links' (NOAA, SeaWifs, tide tables, etc.). and on-line exhibits, e.g. of symmetrical patterns in Oriental carpets.

The site is impressively complete and well-organized and continues to grow as more materials are produced. It has served as an important portal for mathematics educators and as a kind of social center for the mathematics education community.

On-line professional development. In addition to the professional development materials included on sites like the Math Forum, there are entire courses being developed for delivery online. Lesley College in Cambridge, for example, teaches a semester-long online course on technology in education (much of which is focused on mathematics) for pre- and in-service teachers. Other organizations have put together repositories of professional development materials, some of which contain digitized video segments of classrooms and interviews with teachers. This material is of varied quality, of course; being on the Web is no guarantee that something has been well-designed, but it is much easier for teachers to find the resources and judge for themselves than it would be if the materials had to be ordered.

Mathematical communities for students. One of the hopes for the Internet and Web is that they would provide students with a sense of community and audience for the math they are doing—and that these communities might even be international. There have been some successes in this regard (e.g. the Problem of the Week on the Math Forum). While these uses have the potential to engage large numbers of budding mathematicians, they require some human infrastructure to organize students' participation and their impact is still unclear.

Possibility of home-school connections. Another vision put forward for the Web is the possibility that it could enable homes and schools to communicate more effectively. Possible scenarios that have been proposed are: parents and teachers could now have access to the same information about students and might communicate via email; schools might post homework on the Web or send comments to parents about children's work; schools might post materials for parents to use with their children at home to reinforce what they have done in school. There is potential here, but the uses suggested so far don't seem to make a significant leap from the status quo and few of them have been implemented in enough places to assess their effect.

Availability of data. The Web opens up a huge world of data to every student. Data bases that one could never imagine accessing before (seismographic data, weather data, environmental data) are now out there for the taking. Some Web sites have even been created with the express purpose of compiling and supplying databases for statistical analysis (e.g. the CHANCE data base out of Dartmouth). Students can also participate in creating large databases with information culled from a variety of classrooms; if these data are correlated with some geographical variable, students have a particular interest in comparing their data with that from distant schools. The National

Geographic Kids Network was one of the first such projects; measurements of the pH of rainfall and local bodies of water were analyzed to track the sources and effects of acidity. Other examples have been: classroom air quality, butterfly migration studies, and measurements of shadows from different places at the same time. These kinds of projects make students members of a larger mathematical community and give them the opportunity to engage in a mathematical activity that reflects what real scientists do.

The Web will only get larger, with faster connections and more information. We can anticipate that as the amount of material on the Web increases, the difficulty of sifting through all the resources will increase as well. In addition, many of the powerful uses of the Web require human infrastructure as a foundation—organizing a coordinated data collection activity or a math competition must begin with personal contact (albeit over email) that can then make the best use of the Web's capabilities. Getting schools connected to the Internet has been a major policy goal for the past several years; now that we've come a long way toward achieving that goal, it's time to look more critically at the possible uses we might make of these electronic connections.

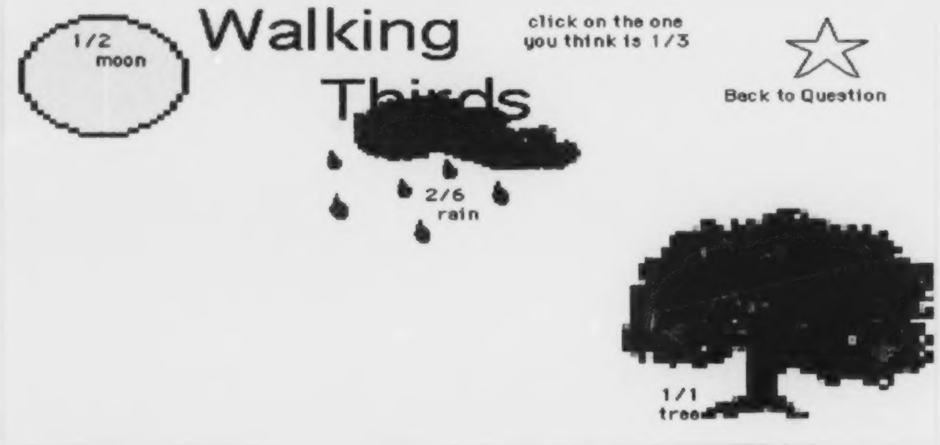
CONSTRUCTION AND DESIGN TOOLS

The increasing power and versatility of computers makes possible uses that are dramatically different from those described above. As computers become potentially smaller and more portable, they can play a central role in the design and construction of artifacts that have personal meaning for students. This approach to technology, which extends beyond mathematics education, has been called "constructionism." Its roots are in the LOGO community; LOGO is a powerful yet accessible programming language in which it is particularly easy to create pictures, animations and simple robot command sequences. Programming in LOGO incorporates math explicitly at times (e.g. figuring out what angles form a regular pentagon), but also introduces students to more general mathematical concepts such as iteration and recursion.

Design activities can engage a wide variety of students, since the actual projects are individually conceived and created. (Witness the unfortunate popularity of Barbie Fashion Designer.) In one recent project that dealt more explicitly with mathematics, students designed and programmed computer games that would teach other students about fractions. Some chose a video game format, others a more narrative approach. (These characteristics were, in general, correlated with gender.) Figure 5 is an example of a screen from one of these games.

FIGURE 5

Screen from a Fraction Game Designed for Kids By Kids

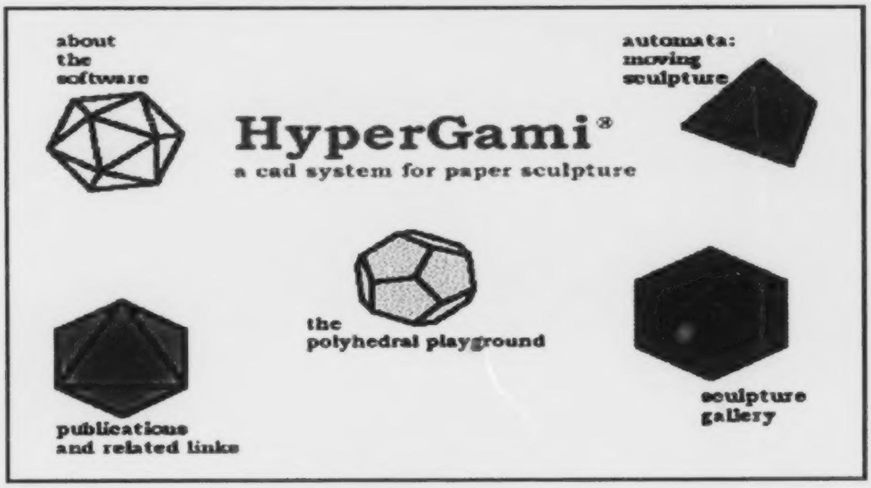


Recently, design activities have been extended even further to bridge the gap between software and physical objects. The most prominent of these is the Lego/LOGO connection, in which students can write programs in LOGO that control Lego constructions. Students have created robots that back up when they hit a wall or other obstacle, miniature amusement park rides, dump trucks, and many examples of kinetic art. A more recent development in the same vein is the introduction of crickets, simple computers the size of 9-volt batteries that contain their own programs and can thus be left on their own to perform tasks such as recording the changing temperature in a room or on a walk, counting the number of times a refrigerator door is opened (and, potentially, catching a midnight snacker), or controlling a light that goes on when someone enters a room.

Physical materials that serve as input or output to software further expand the range of mathematically engaging design possibilities. Scanners provide geometric figures to modify; various visualizing techniques (including MRI's) provide 3D models to be manipulated and analyzed. There are also interesting developments in what can be the output of a software design activity. One recent project that moves in this direction is Hypergami (Eisenberg); in this program the student designs a 3-dimensional origami sculpture using a customized geometric tool, which then creates and prints out the patterns that, when folded, would produce that sculpture. Figure 6 is the opening screen of Hypergami.

Figure 6

HyperGami


about the software
automata: moving sculpture
HyperGami®
a cad system for paper sculpture
the polyhedral playground
publications and related links
sculpture gallery

In the relatively near future, we may have even more imaginative and sophisticated output devices; there are currently laser cutters that can be computer controlled to create custom wood parts for a sculpture. (In an interesting twist, Barbie Fashion Designer has moved in this direction; the material on which the program prints has a fabric-like texture.)

While these materials are just beginning to be used in schools, they have great potential to engage students at their own level, and to encourage collaboration and mathematical discussion. They expand our concept of mathematical thinking to encompass the subtle understandings students must have to actually design something that works—skills they are likely to need later in life and in work.

TOOLS FOR EXPLORING COMPLEXITY

For mathematicians, one of the most important developments in technology has been the increased number of tools for dealing with complexity. From Mathematica, a general algebraic tool,

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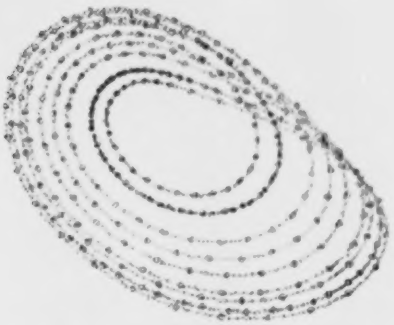
to specific modeling systems (e.g. Agent Sheets) to specially designed languages for exploring large-scale parallel models (e.g. Star LOGO), areas of mathematics that had previously been off-limits for almost everyone are now accessible to students as well as mathematicians.

One type of investigation made possible by such tools is simulation. There are certain natural systems (most popularly, predator/prey systems) for which the basic structure is expressed by a relatively compact set of rules but the behavior can be vastly different depending on the value of a few variables such as the birth and death rates of the predators. Having a tool with which to explore these patterns not only gives students the opportunity to learn about a biological interaction, but teaches them about functions, variables, cyclical functions and sensitivity analysis. Exploring these concepts by hand is practically impossible, since the number of calculations necessary to see any kind of pattern is astronomical. A whole new area of mathematics is suddenly available to middle and high school students.

Even more spectacular is the rise of the field of chaos. Formerly the province of a few mathematicians, chaos is now the subject of books for the lay person and many non-mathematicians have now seen examples of the beautiful patterns created by chaotic systems. Figure 7 is a picture of the Roessler attractor, one of the more basic patterns that arises in the exploration of chaos. This is not the only connection between mathematics and art that technology has facilitated; many middle school students create tessellations with Tessellmania or fractal images with simple programming languages. The implications of the rise of chaos in the mathematical community have yet to filter through the educational system, but the addition of such an engrossing and artistic topic may turn out to be an opportunity to engage and challenge more students.

Figure 7

Roessler Attractor



These examples support the practice of mathematics as an experimental science, an exploratory process of sense-making. As with the dynamic geometry software, rather than giving students a result or theorem and asking them to prove it, these systems provide laboratories in which students can investigate patterns on their own; armed with their discoveries, students can enter actively into a more formal consideration of the underlying mathematical structures.

Systems for modeling complex or dynamical systems can also change the curriculum, as they make advanced topics, whose symbolic representations are inaccessible, available to young students. This is similar to—but perhaps even more striking than—the kinds of changes graphing calculators can make to the algebra curriculum. Other topics in the curriculum may be similar susceptible to the effects of technology. For example, a group of tools under development (SimCalc) makes calculus accessible to younger students (and more understandable to older ones), in part by building technologies that allow students to connect simulations of changes in position and velocity on a computer with similar changes in motions of toy cars off the computer. A classroom set up to use this LBM (Line Becomes Motion) technology integrates graphing calculators with a computer simulation with computer-controlled cars. Between a re-visioning of calculus and the creative use of technology, the SimCalc developers aim to create an elementary through undergraduate curriculum that thoroughly explores the mathematics of change and variation, in ways that every student can understand.

The study of complexity, understandably, has great appeal for mathematicians and students alike; we can explore it today like never before, given the large crop of new tools that have appeared. We don't know, yet, how much this will affect K-12 education—how much more sophisticated mathematics can be made accessible to students or how much these new experiences might engage students who otherwise might not "take to" math.

NECESSARY CONDITIONS FOR TECHNOLOGY TO HAVE A SIGNIFICANT EFFECT ON MATH EDUCATION

It's the realist's turn now. In fact, with all the potential described above, effective uses of technology in math education are not always easy to find. The increasing presence of computers in our schools does not automatically translate into educational improvement. Why? I see four major conditions for change that need to be more consistently met to reap the gains of technological development.

More support for development. Who has paid for the development of the software described above? In some cases, the National Science Foundation has provided funds for prototyping, leaving developers to find other support for bringing the software to market (which often involves a great deal of time and money; prototypes are often quite far from marketable products). Geometer's Sketchpad and Fathom required a significant investment from a commercial publisher; SimCalc is not yet commercially available; the developers of CamMotion were never able to get it published; the Math Forum was begun by and continues to be partially supported by the NSF. Where software has not been published, it is often because no commercial publisher is willing to invest funds into what appears to be (and mainly is) a small market. We have a serious Catch-22 situation here: if there is only a small selection of available math education software, schools will not see that as a reason to buy technology; if there is a small base of computers in schools, publishers will continue to be cautious about putting their own money into development. (This is closely related to the issue of curriculum integration, discussed below.)

Another manifestation of the same problem is that of keeping up with the changing state of hardware. Many teachers bemoan the fact that Apple IIe's are no longer in their schools, as many pieces of software that ran on them do not work on more recent machines. As schools upgrade their machines, software that worked just fine stops working when a new operating system in installed, often at most inconvenient times. Keeping software up to date requires considerable resources (Microsoft and Apple spend large parts of their budgets on compatibility) and educational materials publishers, through whom some software is distributed, often do not have the infrastructure for making software work on different platforms and revising it as systems change.

Curriculum integration. Another critical prerequisite for successful use of technology is its integration into the curriculum. While the most motivated and informed teachers will figure out themselves how technology fits into their teaching, most do not have the expertise to do so. In this regard, the situation is almost uniformly poor. Even the new NSF-funded reform curricula make little use of technology beyond calculators. Only one of the three elementary curricula integrates computer technology at all—and this only minimally. Of the five middle school curricula, one is heavily based on technology, while the other four contain little beyond recommendations for related software. All of the secondary curricula integrate graphing calculators and several make suggestions for using other software, but here, again, there is not much support for teachers who have little experience using technology in their mathematics teaching. Some good curriculum units exist that make use of particular pieces of software, such as dynamic geometry software like Geometer's Sketchpad or data analysis software like Fathom, but these are published separately from the standard curricula.

This situation makes the Catch-22 mentioned above even worse. There are even fewer examples of good software-curriculum integration than there are pieces of software, so schools are less likely to see the value of spending money on technology. Curriculum writers are then loathe to link their products too closely to technology, lest schools without computers decide not to use them.

Beyond content integration, most curricula do not provide support for the logistics that successful use of technology requires. Secondary schools often have self-contained computer labs, which makes logistical planning easier, but elementary schools may not; a common arrangement is for many of the computers to be located in classrooms, in groups of three to five. Even if schools have computer labs, scheduling time in them is often difficult. In order for teachers to fit technology into their teaching, they must have the curricular flexibility to accommodate these different arrangements. One of the NSF-funded elementary curricula, *Investigations in Number, Data, and Space*, includes detailed instructions for teachers about using computers in different configurations, but this kind of support is unusual.

Considering curricular requirements could actually influence decisions about hardware purchases and how they are arranged, but this seldom happens. Schools may set as their goal to "have a computer lab" or "have one computer in every classroom" or "be connected to the Internet," but these plans are often not informed by the pedagogical context in which the technology will be used.

Professional development. Following closely on the heels of curriculum integration as a necessary condition for technology implementation is professional development. This is a difficult task, because teachers need to learn about both the computer itself—how to install software, and troubleshoot hardware and software problems—and how to use the software effectively in their teaching. Professional development, where it exists, usually focuses on the former. Learning how to best use software is itself a complex task, because effective integration may require changes in teachers' pedagogical approaches as well as knowledge of content. The NSF-funded reform curricula confront the same dilemma—i.e. the pedagogy assumed is quite different from the way many teachers tend to approach mathematics teaching—and the situation becomes even more complex with the addition of technology. In many school systems, professional development money ranks third in technology-related expenditures after hardware (the major portion of money spent) and software.

Many schools have hired technology coordinators to deal with hardware and software issues, but they rarely work in concert with other curriculum specialists, so there is a frequent disconnect between content issues and technology issues. A more common model is that a class goes to the computer lab for a self-contained lesson and at times the teacher doesn't even go along. A more productive collaboration among teachers, curriculum specialists, technology coordinators and curriculum developers is necessary before technology implementation will be truly successful.

Public education. The general public sometimes suffers from one of two inaccurate visions of technology and, thus, their support in terms of money, expertise, and even political goodwill can be unreliable. Some are over-optimistic about the potential effects of technology, see it as a panacea, and imagine it reducing the costs of schooling while at the same time increasing its effectiveness. They imagine computers that are individually attuned to each student's needs with limited effort on the part of teachers—or students immediately and productively connected to the world's knowledge via the Internet. This point of view can lead to unrealistic expectations and, in the end, to disillusionment with the entire enterprise.

On the other hand, there are those who see technology as a threat to quality education. They view calculators as tools that undercut students' mathematical growth or computers as overused crutches. (This perspective is often related to the belief that reform math is a dangerous proposition because it erodes students' computational abilities.) These views are even more damaging to the future of technology in mathematics education than the over-optimistic ones, since they are not even willing to see what happens before condemning the possibilities.

The images of computers in the media are clearly one reason for these attitudes, especially for the over-optimistic view. Some parents are not aware of the opportunities that technology offers beyond drill and practice of mathematical facts and computational skills; others are not aware of the complexity of using the Web productively. Educating the media more carefully so that they can educate the public should create a more supportive atmosphere for the kinds of creative uses of technology we need to be educationally successful.

CONCERNS AND CAVEATS ABOUT TECHNOLOGY AND MATH EDUCATION

Equity concerns. There is a history of inequity across gender and race in mathematics achievement in this country. While this gap is closing, particularly with respect to gender, technology may be taking its place as the great divider. Just a few statistics illustrate the seriousness of the situation:

- Schools with more than 90% minority enrollment have 16% fewer computers per capita than other schools.
- A recent study of elementary math software games found that only 12% of gender-identifiable characters in the games were girls.
- In a 1998 study, girls consistently rated themselves significantly lower than boys on computer ability.
- Sixty-nine percent of computer scientists are men; 31% are women.

We cannot simply ignore these differences; girls and women are already being cast as the users who will see the computer as a word processor, but will not write challenging software; Mattel has even come out with different computers for girls (Barbie Computer) and boys (Hot Wheels Computer). Plans for integrating technology into the public schools need to take into account the needs and experiences of a variety of groups across gender, class and other group characteristics. (AAUW, 1998)

Some school systems have offered girls-only technology classes; some community technology centers have as well—and organizations such as the Girl Scouts are venturing into the world of computers. Community technology centers also offer access to computers for populations who are less likely to have computers at home. But these efforts are just getting started—and they are not widely known or adopted.

Risks of inappropriate use. While there are many valuable ways to use technology in math education, there are also those that are detrimental. While many of the fears about calculators and graphing calculators are unfounded, it is important that they be used with thought. For example, before students become reliant on graphing programs, they should have the opportunity to construct graphs on their own, including making decisions about the appropriate representation to use, where to put each variable, how to scale the graph, etc. If they do not have this experience, using a graphing program may amount to little more than choosing a graph type from a small menu.

Calculators can also be used inappropriately: it is important that students know how to carry out relatively simple calculations without electronic support, and we do not do students a service by providing calculators all the time. On the other hand, the hardest part of using calculators in real world situations is figuring out which numbers to type in, what operations to use and how to interpret the answer. No amount of practice with rote operations will lead to that kind of expertise.

Another risk is that of using computers to automate drill and practice—also known as drill and kill. Besides being a considerable waste of computational power, this kind of software only reinforces the view that learning mathematics is primarily about calculating quickly, an attitude that we know cuts out many students from being mathematically engaged. In fact, there is evidence that students who use such programs do not do any better in math than those who do not (while those who use simulation programs do appear to do better). Drill and practice software also has the effect of isolating students who are working individually and certainly not engaging them in mathematical discourse.

Trying to replace teachers. It is worth being suspicious of any use of software that proposes to replace teachers, for it must be based on an impoverished view of mathematics education. In this technological age, teachers are more necessary than ever; this is why professional development is so important, as teachers' roles are changing from being lecturer to facilitator or, as one common slogan goes, from being "the sage on the stage to the guide on the side." It is easier to imagine a computer giving a lecture with multiple choice questions than it is to imagine a computer engaging students in a productive discussion of the concept of limits or even of the concepts of odd and even. Most of the attempts at intelligent tutoring systems are, in my view, rather lame—and even if they are successful, they deal with quite circumscribed and relatively minor amounts of mathematics. We must guard against the public conception that teachers are expendable and that the way to save money in schools is to trim their ranks.

Succumbing to Web ecstasy. While there are many valuable uses of the Internet and the Web as discussed above, there is also a danger that excitement over the Web will cloud our judgment about particular activities. People in other disciplines (e.g. language arts and social science) have noticed—and complained about—students' reliance on the Web for information, to the exclusion of libraries and physical books. In a similar vein, using the Internet to carry on mathematical discussions does not make sense if they could also be happening in person, within a single classroom or a single school. Analyzing a large data set made up of information gathered from around the country may be exciting, but if there is no additional information uncovered than there would be in a survey of the school, it may be poorly utilized effort. It is not always possible to know the value of such a data collection activity before it is done—but there is good reason to think carefully about it before embarking. Journeys on the Web are quite prone to getting lost.

CONCLUSION (QUITE BRIEF)

So there it is: rich potential, significant obstacles, and important concerns. Even though they still eye one another with suspicion, the visionary and the realist rest their cases, sit back and watch what happens.

- Your Comments
- Introduction
- Forum Report
- White Papers
- Forum on Technology in Education
- Emerging Priorities
- '96 ET Plan

The Future of Technology in K-12 Arts Education

By Joan Assey

The purpose of this white paper is to discuss the future role of technology in arts education while addressing the impact technology has on teaching and learning in this content area. Beginning with an overview of the goals and national standards for music, theatre, the visual arts and dance, this paper will speak to the essential nature of using technology in arts education and the linkage between learning and technology.

Arts education means using the aesthetic symbols of music, theatre, visual arts and dance to give our humanity form and meaning. Music uses notes, theatre storytelling, the visual arts, images and dance, body movement. Students are thus able to create, perform and respond to the arts. Technology as a tool in arts education can assist students and teachers as they incorporate overwhelming amounts of information related to these symbol systems.

Professional development and support for improving educational outcomes are more that learning the mechanics of the hardware and software. This effort must include the ability to relate the newer technologies to content areas as arts educators develop lesson plans, and deliver instruction and create meaningful assessment. The incorporation of the Internet and distance learning will also change the way students are able to learn. It will connect students to other schools, institutions of higher education and the business communities as well.

Participation in the world of the 21st century will demand technology competence. Today students must use technology to solve problems, make meaningful decisions, think creatively and apply information.

Click here to view The Future of Technology in K-12 Arts Education in pdf format.

To read pdf files, you will need Adobe's Acrobat Reader; if you do not have Acrobat, you can download a free copy from Adobe.

Introduction | Forum Report | **Forum White Papers** | Forum on Technology in Education | Emerging Priorities | Comment Here | 1996 National Educational Technology Plan

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Page last updated on 04/7/00 (cdd)

THE FUTURE OF TECHNOLOGY IN K-12 ARTS EDUCATION

Joan Assey Ed.D.
Office of the Governor – South Carolina
Division of Education, Technology Advisor

I. Introduction and Purpose
II. Technology in Arts Education
III. Link between Learning and Technology
IV. Change in Goals and Purpose in Arts Education-Curriculum, Instruction and Assessment
V. Goals and Standards
VI. Professional Development – Support for Improving Educational Outcomes
VII. Technology's Impact on Teaching and Learning in Arts Education
VIII. Improving Educational Outcomes
IX. Connections to Other Schools, Higher Education, Businesses and Communities
X. Caution Concerning Technology's Use
XI. Conclusion

INTRODUCTION AND PURPOSE

While educators may legitimately debate strategies and methods of education, all agree that participation in the world of the 21st century will demand technology competence. The use of technology is essential in teaching communications, mathematics and science. It is no less important in the arts. Currently in American education, we are experiencing a shift in goals and strategies from teaching the basics to using vast amounts of information. Now more than ever, this change requires students to use technology to solve problems, make meaningful decisions and think creatively. Instead of just learning discrete and isolated facts, students need to acquire skills for applying information whatever the subject matter.

We know that technology is an important tool that can improve our educational system, but today we face the challenge of integrating technology into the delivery of content. Our effective use of technology in the educational process will shift our instructional content from data and information to useful knowledge. It will be an opportunity for students and teachers to access, analyze and apply information—to create new ideas by giving functionality to facts. Digital technologies in all content areas can enhance student achievement by addressing introductory and advanced skills, assessment of student progress and student motivation.

Arts education means using the aesthetic symbols of music, theatre, visual arts and dance to give our humanity form and meaning. Music uses notes, theatre storytelling, the visual arts images, and dance body movement. Technology as a tool can assist students and teachers as they incorporate overwhelming amounts of information related to these symbol systems. They are thus able to create, perform and respond to the arts. Each of these disciplines specializes in applied communications skills that are so important to the workforce of today.

The purpose of this white paper is to discuss the future role of technology in arts education and address the impact technology has on teaching and learning in these content areas. It will begin with an overview of the goals and national standards for music, theatre, the visual arts and dance. Additionally, the paper will discuss integrating technology into the curriculum, instruction and assessment of these disciplines. This is important, since to test our vision for the future, we must review the collective wisdom of the past. Finally, the paper will address the issues educators need to consider in making technology part of arts education.

TECHNOLOGY IN ARTS EDUCATION

Technology in K-12 arts education can be thought of as applied science (anything that uses science to achieve a desired result). It is an extension of a person's capabilities as well as a way of expanding his/her ability to learn. In the past evolving technology has always played an important part in the historical development of the arts. Technology has provided the tools, processes, and materials that assist artists in their creative expression. For example, the record player in music and the camera in visual arts are instances in which technology changed people's understanding of art.

The arts are crucial components of the K-12 curriculum and require serious study. Music, theatre, the visual arts and dance are basic means of communications. They develop higher order thinking skills while engaging students in a variety of learning styles. These unique experiences integrate learning with other content areas by showing connections. The arts develop discipline while preparing students for their adult lives. Arts education enables students to acquire aesthetic judgment which affects both individual and group decisions about our society. Students who experience the arts are able to solve problems, make meaningful decisions and think creatively.

While recognized as essential fields of learning in and of themselves, the arts provide significant opportunities for critical thinking, creative problem solving, collaborative learning and community involvement. These interpersonal skills are supported by the findings outlined in the SCANS report (Secretary's Commission on Achieving Necessary Skills-1992) as necessary for the jobs for the future. In addition, the arts provide knowledge of our own cultural heritage and teach us about other cultures both past and present. Moreover, the arts invite students to address fundamental issues such as values, feelings, ethics, standards and social concerns. Mastery of communication skills can be demonstrated through music, theatre, the visual arts and dance.

Now the potential of digital technologies, specifically computers, video and telecommunications have the same power to redefine students' creative expression and understanding of the arts. The applications of these and future technologies will not only redefine what constitutes art, but they should be an essential part of the evolving K-12 curriculum. These newer digital technologies related to the arts force students to be active participants in the learning and creation of the arts disciplines; therefore, it is imperative that arts educators develop a philosophy and incorporate technology with the learning process. Teachers need to create new learning opportunities not just automate the existing curriculum.

Educational technology has three major contributions to make to teaching and learning. First, the use of technology can accelerate the learning in the arts. Students studying music are able to compose their own arrangements and compositions. They can perform a passage on a MIDI keyboard into a notation program. The computer will notate their performance and then the students can compare the notated performance to the original. Also the notation software provides a tool for students to create and print out music. A printed piece of music is a tangible outcome that can be used for assessment.

Secondly, technology can access more information related to any topic. Students and arts specialists using the Internet or distance learning can access the major museums as well as conduct research for specialized articles on art criticism or aesthetic valuing. Many of these experiences incorporate interactive media that engages the learner.

Finally, the Internet can serve as a method of multiple communications among numerous individuals, organizations and communities involved in the arts. Teachers can communicate with thousands of other teachers for discussions about the arts, share lesson plans and organize collaborative learning experiences. It can ameliorate problems like teacher isolation.

At the same time arts specialists must develop personal perspectives on the current and future role of technology in education. They need to determine which electronic tools are appropriate for given classroom situations. In turn, the technology tools will empower them to teach more effectively and use their time more efficiently. Integrating technology with the content disciplines also improves teaching skills and classroom management.

The International Society for Technology in Education's (ISTE) teacher standards established in 1992 address the technology needs for educators. The three areas that teachers need to master are 1) basic computers/technology concepts, 2) personal/professional use and 3) applications in instruction. The National Council for Accreditation of Teacher Education (NCATE) modified these very same concepts in 1995 as proposed technology standards for teachers. According to NCATE, teacher preparation programs are expected to include experiences with educational technology integrated with instruction and assessment. Many of our institutions of higher learning are currently challenged with meeting these standards as they prepare preservice teachers for the teaching profession. Mastering these concepts with meaningful curriculum and instruction is beginning to be a part of the preservice program for prospective arts educators.

LINK BETWEEN LEARNING AND TECHNOLOGY

Howard Gardner's theory of multiple intelligences gives meaning to educators as they define the K-12 curriculum. He believes the purpose of school is to help students grow in all seven intelligences. Teachers need to develop the musical, spatial, bodily kinesthetic, intrapersonal and interpersonal intelligences of their students. These five intelligences must be added to the linguistic and mathematical intelligences already emphasized in American education. This understanding of developing all seven intelligences has powerful implications for instruction and assessment regarding individual and differential development for students and arts education (Gardner, 1983).

As the goals of education change to reflect the new educational needs of our society, so do the strategies for technology integration. It is the belief of our time that the purpose of education today is to prepare students with critical thinking skills for a complex world as well as produce lifelong learning. Learning theorists have created two very different theories for achieving today's educational goals.

One view, ***directed instruction***, focuses on teaching sequences of skills that begin with lower-level and build to higher-level skills. The objectives clearly match with the test items while emphasizing more traditional teaching and assessment methods. Educators stress individualized work rather than group work. Examples of this method are lectures, skill worksheets, activities and tests with specific expected responses. Technology applications under this method are drill and practice and tutorials.

The other strategy, the ***constructivist model,*** focuses on learning through posing problems, exploring possible answers and developing products. This method incorporates problem solving and research skills while stressing group work more than individualized work. It is learner centered in its approach. Examples of the constructivist model contain open-ended questions, research, product/performances and assessment.

Multimedia and telecommunications applications can apply to either the directed teaching method or the constructivist model depending how the arts specialists choose to integrate the digital technologies. Arts educators will determine the instructional need and then identify the technology integration strategy. By combining directed and constructivist activities involving technology and arts education, the teachers will be delivering a more useful curriculum (Roblyer, Edwards and Havriluk, 1997)

CHANGE IN THE GOALS AND PURPOSES IN ARTS EDUCATION-CURRICULUM, INSTRUCTION AND ASSESSMENT

Educators want all students to be able to solve problems, make meaningful decisions, and think creatively. At the same time the goals for arts education must support the best characteristics of quality learning with the latest advances in learning theory and interactive technologies. Arts educators want to teach students how to locate, access, and apply information in all disciplines.

No longer is exposure to the arts sufficient; the visual and performing arts require serious study. The arts in public schools are not just about drawing turkeys at Thanksgiving, learning musical compositions for band competition, reciting lines from Shakespeare or performing folk dances in PE. Instruction in each of the disciplines relies on a sequential curriculum with clearly specified outcomes. The teachers must utilize national and state standards as their measure and incorporate instructional and assessment components in their delivery. Integrating the arts with technology is most important in this information age. By introducing new digital technologies teachers are exposing students to new arts media.

Technology can assist teachers in rethinking their instructional process. Methods of instruction are changing as we integrate the technology with the arts. Arts specialists in each of the disciplines assist students with defining problems, searching and retrieving information and coaching for presentation or performance. By integrating technology with the content, arts specialists can customize instruction enabling students to reach their potential. Very often instruction becomes more interesting because it is interactive.

Arts teachers need to assess the content and instructional delivery of the learning. The key to assessment lies in the curriculum design. It must be created to achieve clearly defined objectives based on skills and knowledge, not on vague feelings, emotion or effort. The arts are performance based and can be judged by measuring the different objectives in music, theatre, the visual arts and dance. Portfolio collections as well as paper and pencil tests will tell how the students mastered the content. Students and arts specialists are held accountable by their communities for meeting national and state approved achievement standards for the arts. Evaluation is important because the public will fund successful programs.

GOALS AND STANDARDS

In **A Nation at Risk** (1983) the Carnegie Foundation discussed many changes necessary to improve America's approach to our educational system. One of the suggestions was to integrate technology with the teaching and learning process. In **Goals 2000: Educate America Act** (1994) the United States identified the arts as one of 9 areas where students needed to demonstrate competency. As part of this action, national standards for the arts were created as well as thoughts about integrating technology with the content areas. It was at this same time that Secretary of Education, Richard Riley, created a National Long-Range Technology Plan to strengthen the role of technology in school reform.

Today technology is already making structural changes in our educational system. Teachers, administrators, and content specialists in music, theatre, the visual arts and dance have been addressing changes to curriculum/content, the physical learning environment as well as the changing roles of teachers. The professional organizations for each of the arts disciplines and some state departments of education have created desired goals and standards to guide curriculum. Yet it is important to note that a major finding in the NAEP 1997 Arts Report Card reported that most schools in the NAEP study followed a district or school curriculum for music and visual arts but not for theatre and dance.

MUSIC

The Music Educators National Conference (MENC) created nine national standards:

1. Singing, alone and performing with other, a varied repertoire of music.
2. Performing on instruments, alone and with others, a varied repertoire of music.
3. Improving melodies, harmonies and accompaniments.
4. Composing and arranging music within specified guidelines.
5. Reading and notating music.

6. Listening to, analyzing and describing music.
7. Evaluating music and music performances.
8. Understanding relationships between music, the other arts, and disciplines outside the arts.
9. Understanding music in relation to history and culture. (1994)

Standards 1-5 focus on skills related to creating or performing music, and 6-9 are objectives related to responding to music. Technology can be used in each of the areas once the music teachers build their instruction upon national and state standards as a guide. At the same time the music specialists must decide how technology can best serve the desired outcomes. For example, electronic keyboards are being used as classroom instruments and the computers are creating and composing music in many music classrooms today (Rudolph, 1996).

THEATRE

Related to the K-12 curriculum, drama education includes theatre experiences ranging from informal role-playing and improvisation to plays for an audience on a school stage. While drama has a limited presence in educational programs in public education, it is an exciting opportunity for students to learn how to communicate with each other. Interpersonal skills are developed by the experience of expressing a person's humanity as well as collaborating with others. Drama education's professional organization, the American Alliance for Theatre and Education, has outlined four goals from their model curriculum:

- to develop internal and external personal resources,
- to create drama/theatre through artistic collaboration,
- to relate drama/theatre to its social context,
- to form aesthetic judgements (American Alliance for Theatre and Education, 1987).

Video technology and various applications software are available to assist the theatre experience by offering both the teachers and students choices to improve the delivery of the curriculum. The camcorder can capture the students' participation in theatre. It also is an invaluable tool for assessment as students create portfolios of their best work. Video communication in its own right is a multimedia art form that addresses the interest of the students in all grades. Many students want to be part of the school's news and video programs. Students at the middle and high school level can use application software to help with set design, costuming, computerized lighting and sound control boards. In addition, students use word processing applications for script development and managerial tasks related to the box office.

VISUAL ARTS

The National Art Education Association (NAEA) defines a quality arts experience as one that involves students in a sequential program where students learn the following concepts:

- to develop, express and evaluate ideas,
- to produce, read and interpret visually-oriented world,
- to recognize and understand the artistic achievements and expectations of civilized societies. (Quality Art Education: Goals for Schools, 1986).

Many visual arts programs use a DBAE approach that provides a strong background for all students. As a philosophy of curriculum design Discipline-Based Arts Education (DBAE) creates a framework uniting art production, art history, art criticism and aesthetics as part of the learning experience. Related to art production or performance, technology has produced new learning in the visual arts. After all, designing the graphical look of software is an exercise in visual arts and design. Digital technology has become a vehicle for creative expression as well as a source for arts information. Electronic drawing, computer animation, video digitizing and multimedia activities are parts of many art classes that have the integrated technology in the program. Digital image capture is the combination of many technologies—an easy mix of photography, video, and drawing on a computer. Scanners for computers allow students and teachers to add images to current works.

Computer art applications make it possible to do time consuming tasks while keeping the original work. They can handle some graphics procedures better than the traditional ways before the use of the computer. Newer technology expands the range of opportunities for creative expression in the art classroom by introducing ideas such as *iteration in pattern generation* (repeat tasks) and *morphosis* (ability to gradually change one form to another). Creative possibilities of computer art go beyond imitating traditional media. It also has become a tool for storing art information and managing the everyday classroom activities. Art specialists need to help their students become competent in this powerful art medium.

DANCE

While only 4% of our schools have dance as part of arts education, this discipline is an opportunity for students to understand dance as an art form while recognizing the body as an instrument of creative expression. Curriculum guides created at the national and state level deal with aesthetic perception, kinesthetic sense, creative expression, choreography and dance criticism. Dance can serve both as an art form for perceiving and a language for communicating. It is an opportunity for students to cooperate with others while communicating emotions through movement. Without dance students are denied access to a significant area of human knowledge (Dance Curricula Guidelines K-12, National Dance Association, 1988).

Technology can be incorporated in a variety of ways to assist dance education. It can be used to document and analyze the dynamics of movement. computer-aided choreography gives dance educators the ability to work out ideas of space and movement on screen without bringing the dancers together. Computer software created as a movement notation system allows teachers and students to create and edit dance notation scores very quickly. And similarly to theatre, sound and lighting technology are part of the dance performances (Robinson and Roland 1994).

PROFESSIONAL DEVELOPMENT-SUPPORT FOR IMPROVING EDUCATIONAL OUTCOMES

Well-trained teachers are the most important part of change and educational improvement. They need preservice training before they enter the classroom and throughout their careers. Just providing the computers and the software will not accelerate arts education. Arts specialists need to have active staff development to develop the knowledge, skills and understanding necessary to relate the newer technologies to the content areas. Teachers realize that technology can change what students will be able to learn; therefore, they need to learn what technology can add to their subject area.

Learning the mechanics of the hardware and software is the first need of educators followed by developing lessons that integrate the technology. Teachers also will learn a new set of instructional strategies moving from a teacher-centered classroom to student-centered learning. In addition, educators who go online can access a wide range of resources, discussion groups and projects. Once arts educators learn how to tap these resources, training becomes easier.

The teachers also need to address meaningful assessment that will validate the success of the learning objectives. Assessment in the arts is a terrific opportunity to use technology to record successful learning experiences by creating a collection or portfolio of best works. Only then can teachers share the evaluation or examples of instruction where technology accelerated the learning or created new artistic opportunities that did not exist before. Powerful staff development provides teachers with classroom assessment skills that allow them to regularly monitor gains in student learning. Inservice opportunities cannot accomplish this task alone.

Teacher training programs require support and time to experiment with the new technologies and develop lesson plans. Arts specialists can learn better and at a lower cost from each other. An arranged mentorship program can assist teachers in collaborating with each other. Inservices for arts specialists that use technology connect teachers to teachers within and beyond their schools; this type of ongoing coaching creates a culture that encourages innovation and collegial sharing of ideas. Only with support and training of teachers will technology support the improvement of educational outcomes for students.

TECHNOLOGY'S IMPACT ON TEACHING AND LEARNING IN ARTS EDUCATION

Multiple use of WEB technology to thousands of Internet sites can assist with the educational process. Arts specialists can find a wide range of resources, lesson plans, discussion groups and teachers eager to collaborate on various arts projects as well as a dialogue with other art specialists. Online courses for students and teachers are beginning to appear in virtual high schools and institutions of higher learning. Some states have created online courses aligned with content standards. The Virtual High School Consortium comprised of 43 high schools in 13 states has created high school courses for students and professional development for teachers. The 1999-2000 course schedule lists 7 fine arts courses. One example, *Music Composition and Arranging* has students using computers, music writing and sequencing software, MIDI and keyboards. In addition to the course objectives, the students also will work on collaborative web based musical compositions.

Distance learning exists now in every state. Today this form of telecommunications teaches sophisticated content to high school students through interactive classrooms and online courses. The SC School for the Arts and Humanities insures that its instruction programs, lectures and professional development are available to all students and teachers of the state.

The Massachusetts Institute of Technology is researching new digital techniques for music, dance, storytelling and the visual arts. They feel the students that have become very fluent with the new technologies will be more expressive with those technologies than previous generations. Researchers at MIT believe digital technologies will become extensions of existing tools artists of today use; they will provide a wider range of expressiveness.

Yet we need more research on the use of technology in arts education. We need the active effort of the federal government to keep the momentum going by continued investment in educational technology, effective use of technology in outstanding programs and improved professional development. More long term research studies with empirical evidence are also needed so we can study the findings and recommendations that address the effectiveness and impact of technology integration. Positive assessment will establish accountability and validate future expenditures.

IMPROVING EDUCATIONAL OUTCOMES

Experiences integrated with technology not only have students create new products and performances, but they also develop computer literacy in students by helping them be better producers and consumers of technology. An arts program that develops students' potential for innovation in music, animation, graphics and multimedia prepares students for the job market of today. Arts specialists must discover the educational vision behind each of the digital technology teaching tools as they integrate the technology with national and state standards, instructional strategies and assessment.

Robinson and Roland (1994) offer four positive outcomes for students as they integrate technology with music, theatre, the visual arts and dance. Students who experience technology with the arts interact with new modes of artistic expression, and they have a better understanding of the present technological age while developing computer literacy. The teachers develop students' potential for the job market and assist students in keeping their aesthetic sensibilities in the face of technological advances.

Arts specialists have always advocated active participation as a key component for effective learning. Now we see an increasing number of educators using computers to teach music, drama, dance and visual arts. Some of the best learning experiences come when students are involved in designing and creating; yet our lock step curriculum has limited these worthwhile experiences. Now digital technology no longer confines arts experiences to limited interaction; it extends opportunities in types, time, and access to more resources. The students who effortlessly use the new technologies of today are more able to use them for creative expression as the world becomes their classroom.

Technology also changes what students are able to learn. Before educators have distinguished between schoolwork and homework. Now when the computer is on, students can learn at the same intensity at home as well as at school. Students are free to move through the curriculum according to their own pace with periodic assessment. Because all students do not learn the same way or at the same time, they will progress through the curriculum while becoming independent learners.

CONNECTIONS TO OTHER SCHOOLS, HIGHER EDUCATION, BUSINESSES AND COMMUNITIES

With new technologies, communities extend beyond neighborhoods or school attendance areas to include anyone interested in certain topics or issues. Students are virtually connected to people interested in the arts as well as the entire arts community through electronic networks. Technology is giving parents, other schools, higher education, businesses and communities the opportunity to become more involved in students' education. Students can communicate with others as easily as if they were physically present in the school building.

Museums are placing their whole collections on line and using technology to assist with art analysis and discussion. The Guggenheim created a digital production studio with the ability to send the short videos out over the WEB. An interactive music learning center for children has opened in New York City where young people plug in their hand held instrument boxes into a computer system demonstrating rhythm and pitch. Many of the recent arts education grants from the National Endowment for the Arts have technology components attached to their goals.

Distance learning can also be a link for course delivery and communication among different members of communities. Distance learning refers to learning situations in which the instructor and learner are separated by time and space. By using this example of electronic networks, arts specialists can use people not in the classroom as part of the instructional delivery.

Communications technologies require changes to the traditional classroom structure. Distance learning for K-12 very often relies on the problem solving expertise of both higher education and the industrial world. In addition, community involvement can be part of the learning experience allowing unlimited learner access to programs of choice. The same technologies that allow for universal access to learning also foster a growing sense of community.

CAUTION CONCERNING TECHNOLOGY'S USE

Because technology will play such a key role in job opportunities for the future the uneven distribution of technology based on income, gender, race or geography could widen the social divisions that exist in our society today. Computers have the ability to create a more equitable learning environment in which all students can access the Internet, telecommunications and multimedia resources. We must be aware of equity related to distribution, training and access and create multiple strategies to make sure access to technology exists for all students.

As teachers work with integration of technology to the arts disciplines, it is important to keep the curriculum, instruction and assessment in focus. The most successful application of technology will be combining the best learning theories and instruction with digital methods. The instructional programs for students and teachers cannot be overshadowed by the technology. In other words, the technology cannot become more important than the arts content or curriculum. In addition, teachers and students need to learn to deal with the chaotic information that exists so they may become wise consumers of information technology.

CONCLUSION

Our society is changing from an industrial age model to one immersed in technology, and our schools are beginning to adapt to this change. Technology is affecting the way we develop curriculum, deliver instruction and assess student learning in arts education. While the content in the arts disciplines is most important, technology in the hands of professional arts educators will provide students more varied and challenging experiences and the ability to work at their own pace. Technology will also provide the resources for students to take charge of their learning.

The potential success of using technology for better learning experiences in arts education rests with the teachers. Arts specialists can choose the way technology integrates with the curriculum, and they are beginning to use technology in various instructional and assessment situations. Arts specialists not only need continued training in basic computer skills, they need professional development in specific hardware and software related to improving the learning experience in each of the arts disciplines.

Educational systems, professional arts organizations and arts specialists should lobby for technology to be part of the arts classroom. As educators, we should also ensure that both preservice and inservice teachers have professional development opportunities that address delivering the curriculum standards, instruction and assessment with technology integrated in each part. It will take all members of the arts education community to prepare our students to become performers and consumers of the arts while realizing the lifelong benefits.

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Toward a Vision of the Future Role of Technology in Literacy Education

By Linda Labbo

The purpose of this paper is to suggest how technological innovations are likely to play a role in America's quest to provider her children with an effective literacy education that prepares them to succeed in their future endeavors. The paper explores an emerging vision of the future role of technology in literacy education in the near-term and offers brief closing comments about long-term possibilities

The paper begins by introducing three key factors that relate literacy instruction as it has occurred in the past, present, and near future. The three factors include: Definitions of literacy, predominant learning theories and classroom communicative technologies. For example, in the best of all possible words, the definition of literacy adopted by educational institutions will mirror mainstream society's definitions of and expectations for what it means to be literate.

Digital reading and writing, that is reading and writing on a computer, has permeated all aspects of daily literacy activity in the U.S.A. Emailing, internet access to information, and word processing are literate acts that employed by people for personal, professional, and business communications. How work is done is largely being recrafted by computer-related techologies and requisite literacies. Digital literacy relates to the ability to comprehend and use information in multiple modes as it is presented on a computer screen. To be digitally literate, one will have to be able to navigate, locate, communicate on-line, participate in digital, virtual and physical, communities. Literacy definitions in the future will relate to informatic abilities - a range of meaning-making strategies required to assemble knowledge in cyberspace.

Teachers in future classrooms will assume flexible instructional roles (Model, Mentor, Manager) that supports effective computer-related literacy instruction. They will use software and internet links to support children's traditional print-based literacy development; however, they will also be well prepared to support children's digital literacy-development as well. A crucial part of digital literacy instruction will involve helping students acquire critical literacy and reasoning required for assembling and evaluating information from the internet

We have many questions that remain to be answered about effective use of computers for digital literacy instruction in the classroom. However, the time has come when we must formulate a vision for effective computer-related literacy practices.

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TOWARD A VISION OF THE FUTURE ROLE OF TECHNOLOGY IN LITERACY EDUCATION

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"'I am the Oz, the Great and Terrible.
Why do you seek me?' . . .
Dorothy asked, 'Where are you?'
'I am everywhere,' answered the voice,
'but to the eyes of common mortals I am
invisible.'. . . As it [the screen] fell with a
crash they[Dorothy, Tin Woodsman,
Scarecrow, and Cowardly Lion] looked
that way, and the next moment all of them
were filled with wonder. For they saw,
standing in just the spot the screen had
hidden, a little old man, with a bald head
and a wrinkled face, who seemed to be as
much surprised as they were. 'Who are you?'
'I am Oz ..." (Baum, 1973, p. 262-263 [emphasis added]).

"Pay no attention to that man behind the curtain."
(from the movie version of *The Wizard of Oz*)

It was an earthshaking moment for Dorothy when she first realized that all of the marvels, bells, whistles, magic and trials she had experienced in the Land of Oz during her quest for a way home were being manipulated by a small, balding man, in a rumpled suit, who was frantically operating complex technological devices behind a screened curtain. In the very moment that Dorothy recognized the previously hidden technology for what it was, a powerful means for extending and enhancing one's power within the environment, she experienced a profound paradigm shift that allowed her to reconceptualize her quest as one that was attainable. No longer a witless victim of technological powers ruled by others, she became empowered.

The purpose of this paper is to draw back the curtain on the future just a little bit in order to catch a glimpse of how technological innovations are likely to play a role in America's quest to provide her children with an effective literacy education that prepares them to succeed in their future endeavors. The paper explores an emerging vision of the future role of technology in literacy education in the near-term and offers brief closing comments about long-term possibilities. It is unlikely that the contribution of this paper will result in a *Dorothy Moment*—an overall paradigm shift in the educational field that recognizes that literacy-related use of computers in classrooms offers a means for extending and enhancing one's power. It is more likely that this paper may take a small step forward by inviting others who are interested in this important topic to participate in a conversation that may help all interested stakeholders craft a clearer vision for the best uses of computer-related technology in the literacy curriculum—a shared vision that will empower us to chart an appropriate course, establish worthy goals, and garner necessary resources to enact the vision.

The paper is organized into the following sections:

- Introducing 3 Key Factors
- Laying a Groundwork: Brief Glimpses from Past and Present Decades
- Forecasting the Future of Literacy Education: The Wizard is Back!
- Asking Questions: Cautions Worth Raising
- Concluding Comments: Ready or Not, Here It Comes!
- References

(Note: For those who wish to read this text in a more hypertextual, nonlinear format, or for those who wish to begin with reading about the vision for the near future, I provide the following outline of the relevant section which appears towards the end of this paper: Forecasting the Future of Literacy Education: The Wizard is Back! (1) Anticipating Societal Literacy Expectations; (2) Forthcoming Definitions of Literacy as Digital; (3) Counting on Computer-Equipped Homes; (4) Formulating Relevant Learning Theories; (5) Venturing into the Vision.)

INTRODUCING 3 KEY FACTORS

For purposes of this discussion, I have attempted to simplify many of the complexities involved in considering the role of technology in literacy instruction by focusing on three key factors. Although many multifaced elements influence literacy instruction (see Labbo & Reinking, in press, for a more complete exploration of multiple philosophical orientations that guide technology-related literacy instruction), the type of literacy instruction that has occurred, currently occurs, and will most likely occur in future classrooms in America tends to feature the following three factors:

1. Definition of Literacy
2. Predominate Learning Theory
3. Classroom Communicative Technologies

Definition of Literacy: In the best of all possible worlds, the definition of literacy adopted by educational institutions will mirror mainstream society's definitions of and expectations for what it means to be literate. In other words, educational goals and purposes for literacy instruction should reflect a synergistic relationship with society's expectations for how literacy is utilized and valued in various societal endeavors. That is not to say that every educator or citizen will be able to articulate a clear definition of literacy upon demand, primarily because such a definition is frequently experienced on a tacit level, embedded within unstated but collectively followed cultural practices. Additionally, I do not mean to suggest that there is always an exact alignment between academic literacy that occurs at different levels of children's literacy development and societal literacy. However, in an era when computer-related, communicative literacy abilities are proliferating throughout all aspects of life in American society and throughout the global marketplace, it is crucial to explore a vision for the role computer-related literacies should play in defining children's literacy development in school in the near future.

Predominate Learning Theory: Predominant learning theories are important to consider because they provide insights about underlying instructional frameworks that allow us to understand the nature of literacy instruction. Experts who write literacy basal series and curriculum guides are frequently guided by the most current and widely-adopted learning theories. Additionally, teachers conceptualize their instructional roles as literacy teachers in light of their deeply held philosophical underpinnings and their understanding of learning theories. The philosophical framework that undergirds instructional decision-making will in large part determine how communicative technologies are used or not used within the walls of a classroom.

Classroom Communicative Technologies: Communicative technologies - sets of tools, devices, materials, and the processes people engage in when using the tools to perform a range of literacy functions—are important to consider because they speak to the range of literacy-related instructional practices that are possible within a classroom. That is, the presence and use (or nonuse) of available technologies either ultimately supports (or limits) children's opportunities to become literate in ways valued by society. For example, society-at-large, teachers, and literacy curricular objectives may all put forth the expectation that every literate member of our society should be able to send and access e-mail; however, if the communicative technologies to do so (i.e., internet hook up, CPU, keyboard, monitor, software, a link to someone to participate in an email who is also connected to requisite technologies) are not present in the classroom, a literacy discontinuity will develop. Such a *school-society literacy discontinuity* is likely to have serious consequences for students from nonmainstream families with low socioeconomic levels and limited resources because students from mainstream families are likely to have access to complex forms of computer-related literacies at home. If one of the goals of literacy education is to better prepare *all* students to function as literate beings in society, it is crucial to weigh how well the use of communicative technologies present in the classroom coincides with the use of those tools in the larger society.

LAYING A GROUNDWORK: BRIEF GLIMPSES FROM PAST AND PRESENT DECADES

It is beyond the scope of this paper to give an exhaustive historical overview of all past reading instructional practices across time eras or to thoroughly describe all of the possible current instructional practices. Nonetheless, a helpful way to lay a groundwork for effectively establishing a vision for future trends in communicative technology-related literacy instruction is to consider briefly how the three factors—definitions of literacy, learning theories, and communicative technologies - have been exhibited in elementary school classrooms in America during a previous decade, the 1930s, and how they have been manifested more recently in the 1990s.

A GLIMPSE OF THE PAST—COMMENTS ABOUT LITERACY EDUCATION IN THE 1930S

In the 1930s skill and drill lessons geared toward students' mastery of reading skills directly related to behaviorist learning theory, a theory that advocated a stimulus—response approach to learning. Additionally, mainstream society firmly believed that an educated factory-based workforce should be able to read and write at a functional level in order to understand simple work-related instructions and to be able to read newspaper accounts that would allow them to make informed decisions when voting in elections. Thus, notions of literacy were primarily print-based and consisted of reading and writing the printed word.

Communicative technologies such as, blackboards, slates, mass-produced basal reading materials, practice lessons, pens, ink wells, and inexpensive books, supported the goal that students, many of them from families newly immigrated to America, would be able to have adequate skills practice in order to obtain national notions of print-based literacy development (Stokes, 1997), and children's development as laid out on an instructional scope and sequence. For example, published reading basal series and literacy-related literature-based curriculum materials are routinely organized along developmental reading stages (See Chall, 1983), an articulated instructional scope and sequence that loosely lays out organizational frameworks such as the following:

1. emergent literacy (PreK-K) - children construct concepts about print,
2. beginning literacy (1st- 2nd grade) - children learn about decoding and word recognition,
3. fluent literacy (2nd/3rd-grade) - children become fluent readers of connected text,
4. maturing literacy (4th-5th grade) - children are able to read various genres and are also able to read-to-learn content area texts,
5. strategic literacy (6th and up) - children are able to strategically approach various texts for various purposes.

Many teachers view their current instructional role as that of a facilitator and guide who offers children supported practice that allows them to socially construct knowledge about conventional literacy. The teacher mediates children's cognitive processing and opportunities to learn literacy-related skills and strategies through whole group direct instruction, small group interactions, and individual conferences. Home-School connections tend to focus on fostering an ongoing flow of communication that can be used to inform parents about the school literacy program, offer suggestions for appropriate home literacy activities, invite parents to participate in classroom activities and events, and arrange for teacher/parent conferences to discuss the child's literacy progress.

Currently available instructional communicative technologies include resources and devices such as, classroom sets of children's literature, published basal reader series, recorded books on audio tape, Big Books, video tapes and VCRs, dry erase boards, at least one classroom computer center (complete with a 15 - 3 year old CPU, a monitor, a keyboard, a mouse, and sometimes a printer, but few if any ink cartridges or printer paper), CD-ROM talking books, phonic game software, simulation game software, simple word processing software, keyboard practice software, and limited access to the internet. For the most part, when computer-related technologies are used in the classroom, they are considered to be an add-on component to an already full curricular and instructional day. At selected times of the day (when students have free choice or when successful students complete paper and pencil seat work early), computers in the classroom are used for basic skill and drill tutorial practice, publishing a final draft of a paper on a word processor, or playing a simulation game as a reward.

In considering the presence and use of communicative technologies in schools in the 1990s, it should also be noted that the classroom is typically the last institutional location in a society that fully incorporates new technological advances into the way work is accomplished. A gap exists between technology access and use across schools and technology access in the larger society because of school budgetary constraints and a lack of effective professional development for teachers (Papert, 1993; Reinking & Bridwell-Bowles, 1991). For example, in spite of recent excellent initiatives, such as the U.S. Department of Education National Educational Technology Plan, *Getting America's Students Ready for the 21st Century*, disparities in classroom connections to the internet exist across socioeconomic levels and geographic regions. A case in point is provided in persuasive statistics. Schools with only 11% of students eligible for free or reduced price school lunches had 62% of their classrooms connected to the internet while schools with 71% or more students in the same category had only 39% of classrooms connected (NCSS, 1999). Additionally, newer technologies are often expensive and prone to short-term obsoletness, a situation that occurs more often than not when newer versions of computer-related technology appear on the market within a few short years or even months after a school computer purchase. School boards sometimes adopt a wait-and-see attitude that results in schools being left in a computer-related technological gap with use of technology in society.

Educators of the 1990s are faced with the enormous task of preparing students to be literate in a future that is unclear and for a level of computer-related literacy that many educators themselves have not yet grasped (Leu & Kinzer, in press). There is little doubt that a generational technological gap exists in many classrooms between what teachers know about using computers and what their students know. Therefore it comes as little surprise that teachers across the nation do not routinely integrate available computer-related technologies into their everyday literacy curriculum (U.S. Congress, 1995). Other reasons come into play: lack of adequate staff development, absent on-site technical support, scant directions or suggestions in Teachers' Editions of published basal materials, outdated computers, little time to evaluate and select suitable software or identify curriculum-relevant Web-sites that may integrate into the curriculum, and glitches, glitches, glitches in operating hardware and software.

The overall goal of literacy instruction in the 1990s, including work with computers, is to meet society's expectation that students will be able to use the language arts of listening, speaking, reading and writing to participate in various discourse communities for various public and private purposes. However, those goals are not always met with great success. Many stakeholders, including teachers, administrators, parents, community members, and tax payers, understandably have become concerned with literacy as it is evaluated in high-stakes, standardized testing/assessment instruments. Instructional time in classrooms may be focused on helping children use literacy in ways that are required on standardized tests. Unfortunately, the type of literacy knowledge, skills, and strategies tested on such instruments are not always reflective of society's larger literacy goals in general and computer-related literacy goals in particular.

FORECASTING THE FUTURE OF LITERACY EDUCATION: THE WIZARD IS BACK!

This section is organized into the following topics:

- Anticipating Societal Literacy Expectations
- Forthcoming Definitions of Literacy as Digital
- Expecting Computer-Equipped Homes
- Formulating Relevant Learning Theories
- Venturing into the Vision

Anticipating Societal Literacy Expectations: The penetration of digital reading and writing into all aspects of daily literacy activity has increased and will ultimately have a profound effect on what is considered mainstream reading and writing (Reinking, 1998) in the very near future. For example, when many Americans want to write a quick note to a colleague, they compose and immediately send it via e-mail on a computer screen. The note will be sent in the same amount of time to a computer in an office across the hallway as it will take to send it to a computer in an office across an ocean. When someone decides to find out the latest international news, he accesses an on-line news service and downloads video clips, audio commentary, or printed news columns on his computer screen. When someone decides to write a report, she is more likely to draft, revise, and edit it on a computer screen with a word processor than with a pen and paper. In these instances, the computer is more than a typewriter or publishing instrument, it is a tool for composing that allows the author to encounter and manipulate ideas on the computer screen.

In the realm of work, information will continue to be used as a major resource for solving problems within America and across the globe (Leu & Kinzer, in press). However, access to information will not be enough as workers need specialized skills for making sense of various data sources found on the Web. Flexible networks, instead of centrally planned organizations, will soon allow people who work in various work-related avenues and locations to collaborate on multiple projects that cross commercial, geographic, business, and national boundaries (Mikulecky & Kirkley, 1998).

Forthcoming Definitions of Literacy as Digital: In light of burgeoning technological accessibility and the observation that print is only one of many communicative symbol forms used in digital realms, it is not surprising that the call of many educational philosophers, educators, and researchers for expanded notions of literacy will be realized in the near future. Reinking (1994) posits that current notions of reading and writing will be expanded to include electronic literacy, the ability to understand electronic text in various forms. It is misguided to view electronic, or digital texts, as nothing more than a printed page displayed on a computer screen.

Gilster (1997), suggesting that literacy should be reconceptualized as a digitally-based, not print-based ability, states: "Digital literacy is the ability to understand and use information in multiple formats from a wide range of sources when it is presented via computers" (p. 1). Elaborating on this definition, he speaks about a merging or convergence of multiple forms of media by explaining how a digital signal carries graphics, animations, audio, video, and text that are sorted out and delivered for interactive manipulation on a computer screen. In other words, informational forms can take on any shape when transmitted as a sort of binary soup that moves, stores, and displays voices, images, linked documents and words within and across computer screen documents. Furthermore, the various informational sources link seamlessly and can therefore be manipulated by consumers of information or producers of information in ways that meet their communicative goals.

Digital literacy refers to a way of processing information that differs significantly from what happens when we read a novel or a letter and the differences are inherent in the medium. Digital content is dynamic and pathways taken are hypertextual, malleable, and idiosyncratic. To be digitally literate will mean to learn skills necessary to navigate, locate, communicate on-line, and participate in digital, virtual, and physical communities. Therefore, literacy will also be seen as *informatic,* involving a range of meaning-making strategic abilities required to navigate through and assemble knowledge from various informational resources in cyberspace (Lemke, 1998; Bruce, 1998). Literate consumers and producers of information must be able to take a critical stance toward sources of information, intended audiences, and the reliability of the information.

Expecting Computer-Equipped Homes: The time is soon approaching when the infrastructure will be in place that allows affordable computers to be present in almost every home (some projections speculate this will be reached by 2006). The technological interface of these devices will be as easy to operate as a telephone. Thus, being digitally literate at a functional level, the ability to access and interact with the ideas through multiple digital symbol systems presented on a computer screen, will be accessible to the larger community. However, unless educational institutions are successful in promoting higher orders of digital literacy processes, one's ability to manipulate data for public and personal communicative purposes may continue to be determined primarily by educational and socioeconomic levels.

Formulating Relevant Learning Theories: Wright (1987) suggests that adequate theories may need to wait until more is known about the optimal formats for displaying electronic and printed texts; however, instead of seeking one overarching theory, it is possible that digital literacy is so complex that it will require multiple theoretical underpinnings. Many several potentially relevant learning theories are likely candidates. For example, *sociocognitive* orientations (Vygotsky, 1978) that are prevalent in the 1990s are likely to remain influential in instructional decision making in the near future. As Leu and Kinzer (in press) observe, social learning strategies will be crucial to children's literacy development because social collaborations, such as group learning among internet project participants, help prepare them for future workplace organizational/decision-making frameworks.

Another emerging theoretical perspective, *semiotics*, has potential for shedding light on digital literacy learning processes and instruction because it combines cognitive psychological and sociocultural learning theory (Lemke, 1998). The cognitive psychology component is grounded in the idea that comprehension and expression of ideas is mediated by students' abilities to interpret signs and sign systems. From a digital perspective, children construct meaning by interpreting an array of multimedia signs (ie., words, icons, music, video) they encounter on a computer screen. However, their interpretations are not mediated by the signs in isolation. Rather from a semiotic perspective, the social and cultural contexts surrounding the signs play a role in meaning making. Thus, the purposes for meaning making, the culturally agreed upon interpretations of the symbols, and the interactions with significant others in the environment all combine to effect meaning (Rowe, 1994). In digital communicative platforms, multimodal symbols available in multimedia software packages give young children opportunities to encounter, select various symbol systems, interpret meanings of the symbols, and consider cultural connotations and contexts involved in expressing the meaning they wish to communicate to a particular audience (Labbo, 1996).

Venturing into the Vision: In the foreseeable future, the man behind the curtain is still busy at work but unlike his counterpart, Frank Baum's wizard, the work he does is not overtly manipulative or sinister but is beneficial. This circumstance will occur because The Wizard and his technologies are so integrated into daily school life, curricular activities, and literacy acts that he has become invisible (Bruce & Hogan, 1998). The future technological Wizards of Oz (ie, the programmers, hardware designers, software designers, curriculum writers, support teams, and architects of the web) have done their jobs so well, that many of the barriers to effective current computer-related literacy instruction have been removed. For example, computers and peripherals are affordable, dependable, and luxuriously present in classrooms. Technological support, when needed, is on-site, on-line, quick, responsive, and sophisticated.

In view of this openly optimistic scenario, I present selected implications for classroom practice that may contribute to an obtainable and potentially desirable vision by considering what teachers will (1) know about computer-related literacy; (2) what computer-related literacy tools they will have access to; and (3) what they will do with computer-related instructional tools.

1. **What teachers will know:** There will no longer be a generational technological gap between students and teachers because teachers will have grown-up in a society that has so embraced digital literacy that computer usage is second-nature to them. Additionally, teacher preparation programs will have learned how to integrate computer-related technology into literacy education course content and delivery (See Kinzer & Risko, 1998, for a discussion of digital case study anchored instruction). However, teachers will have to continue to adopt an attitude of perpetual adaptation as newer technologies enter the classroom.

   Teachers will understand that effective use of computers in classrooms is not a matter of either-or (e.g., either print-based alphabet based instruction or digital multi-symbolic modes of instruction). Rather, they will be very conversant with new definitions of literacy as digital, a definition that encompasses alphabetic as well as multimedia symbolic modes. Teachers will embrace emerging theoretical perspectives on literacy learning as socially constructed and potentially cognitively distributed because they understand that there is a fundamental relationship between cognition, digital features, and digital literacy development.

2. **What teachers will have**: Teachers and students will have access to multiple types of state-of-the art computer equipment and communicative technological devices. They will create and have access to digital tool kits. Digital took kits will consist of previously incompatible applications (e.g., art programs, video clips, email, word processors, electronic books, data bases, internet links) that will digitally converge in a multimedia screenland (Labbo, in press b; 1996) instead of on a computer screen business desk top. Multiple software resources and technologies may be orchestrated to meet students' various literacy needs. For example, a digital tool kit might consist of supported text for reading difficult passages, a space to collaborate with a peer, and a place to record and email thoughts about a passage to others within a learning community.

   In the near future, teachers have an interactive, on-line relationship with each student's family. As a result, many cultural barriers may be transformed into cultural bridges as information becomes a two-way flow. For example, instead of the school primarily informing parents about children's school-based activities, parents will inform teachers about children's home-related literacy strengths in ways that will inform the curriculum and impact students' achievement (Moll, Amanti, Neff, & Gonzalez, 1992).

3. **What teachers will do**: Teachers will (1) assume flexible instructional roles, (2) support children's traditional print-based literacy development, (3) support children's digital literacy-development, (4) foster children's awareness of critical literacy and reasoning.

1. Teachers will assume *flexible instructional roles*. Teachers will be masters of digital literacy pedagogy who are comfortable stepping into out and out of the following flexible roles: Model, Mentor, and Manager (Labbo, in press a). What is unique about teacher roles is that they are perceived by teachers as being flexible because they may be shared with a variety of experts who may be present in the classroom or present on-line.
    - Model: Teachers and expert others will demonstrate the purposes, outcomes, and strategies for use of literacy technologies.
    - Mentor: After introducing and modeling a strategy, teachers will support students' initial and ongoing computer literacy-related projects. Mentors, may consist of the teacher, a paraprofessional, parent volunteers, student teachers, cross-age computer buddies from intermediate grades, more capable peers in class, experts or peers on-line. Teachers will also select specific software applications for its ability to serve as an effective mentor that is programmed to give specific types of feedback to individual students.
    - Manager: Teachers will manage the literacy curriculum to a large degree by allowing it to emerge from children's interests, thematic units, explorations and projects on the web, and authentic inquiry.

2. Teachers will *support children's traditional print-based literacy development*, Software and internet resources will provide teachers with access to various reading and writing tutorial programs that may be selected to meet children's individual literacy developmental needs. For example, children who have English as a second language (ESOL) will be able to access reading practice materials in both languages.

    Children who have difficulties comprehending text will have supportive digital environments on screen that allow them to not only read a text, but have access to video clips of conceptual constructs (e.g., an orbiting planet), definitions of specialized vocabulary (trajectory), links to other textual references (an interactive encyclopedia of the solar system), additional background knowledge (a narration about why it is important to learn about planetary orbits) (Anderson-Inman & Horney, 1998), pronunciations of unknown words, or a mini-lesson that may be tailored to help a child learn how to sound-out an unknown word (a voice prompt

"If you know that J-a-n-e-t is Janet, then pl-a-n-e-t would be ... Planet.") (McKenna, 1998).

Teachers will arrange for children to have in-depth conversations about various types of text with peers in class and with an extended on-line community. Children will have access to word processing programs that allow them to compose and shape their thoughts into communicative forms, instead of using the word processor to type a final draft of writing composed with paper and pencil.

3. Teachers will *support children's digital literacy-development*. Reinking (1987) suggests that computer-mediated text and printed text are separate media and that each format requires unique [approaches] to literacy instruction. In his view, every medium is ultimately characterized by how its symbol systems and technological features interact with cognitive processes. A particular type of medium requires a learner to engage in a unique set of cognitive skills to derive meaning. On a similar vein, Salomon (1994) suggests that every cognitive interaction with digital media leaves an impression of cognitive residue on the cognitive processes and brain of the user. This interacting with features of technology over time may significantly alter the user's cognitive and strategic abilities.

Hypertext, for example, permits texts to respond to the needs of a particular reader but also places a burden on the reader to chart a course through information and make sense of the unique pathway traveled (Reinking, 1987). Hypertext is designed as a nonlinear set of informational modules that are connected by semantic links. Teachers may use various approaches to helping children become able to strategically navigate though hypertext for specific purposes. For example, in initial encounters, teachers may configure a hypertext program to control the number and possible paths of student-text interactions that can occur by limiting the reader's access to specific portions of text. Arranging for various levels of access to different portions of text over time may guide students' development of metacognitive awareness and abilities to make sense of hypertextual documents.

Lemke (1994, 1998) raises the notion that multimedia literacies must be taught in ways that ensure an appreciation for how *converging media multiply meaning*. That is, the act of accessing, comprehending, composing, producing, and publishing ideas in work that integrates disparate media forms such as diagrams, drawings, video clips, voice audio, animation, music, archival photo images, sound effects, etc. must be accomplished in ways that are not possible through the presentation of the same ideas in an isolated medium. Teachers will support students' assembly and production of knowledge through multimedia presentations that highlight the multiplicity of meaning factor (Lemke, 1998).

4. Teachers will *foster children's awareness of critical literacy and reasoning* required for communicating in digital domains. Adults will help children understand that the Internet is made up of a complex universe of interest groups and individuals that range from vanity presses, to lunatics, to altruistic institutions. Students must be taught how to critically comprehend and challenge information they encounter through careful analysis of Web pages and Web links (Leu, 1999, personal communication). For example, teachers can arrange for a collaborative learning workshop that is designed to compare information on the same topic drawn from various Web pages. After noting that there are broad discrepancies, not only of opinion but of facts represented across pages, students will benefit from a discussion of how to figure out which sources are reliable and why.

ASKING QUESTIONS: CAUTIONS WORTH RAISING

How will children's literacy development be viewed in the near future? In short term, the paradigm shift from an understanding of literacy as totally print-based to literacy as both print and digitally-based, curriculum writers may attempt to superimpose a new scheme on an older, traditional developmental scope and sequence. For example, the progression might be characterized in the following stages: digital literacy conceptual development level (PreK-K), digital literacy acquisition (1st-2nd grade), digital fluency literacy (3rd-4th grade), digital strategic literacy (5th grade), digital aesthetic literacy (6th-7th grade), to digital critical literacy (8th grade and up). The problem with such organizational frameworks is a lack of a research base or an experiential base to support it. It is likely that multi-age and cross-age collaborative projects will place increasing pressure on curriculum developers to reconceptualize how children acquire and develop digital literacy in ways that challenge traditional notions of development.

Can we expect computers to offer a quick-fix for classrooms where children struggle to attain literacy? Computers in classrooms in the near future will not result in a quick-fix for remediating all of the literacy instructional problems experienced in classrooms or in society at large. Digital literacy is as complex, if not more so, as print-based literacy. Digital literacy instructional issues are complex and will no doubt create unique sets of difficulties that will need to be sorted out.

Technology is changing so fast, isn't it safer to wait a while before investing in computers for classroom and in substantial staff development efforts related to digital literacy instruction? Leu & Kinzer (in press) make the observation that societal forces preclude adopting a wait-and-see attitude that is intended to allow a sufficient level of computer development and research to amass before making efforts to equip and use computer-related technologies in classrooms. They elaborate in the following statement. "... A preeminent group of scientists and educational researchers in the U.S. recently argued that ICT ... Were so central to the future of the U.S. That additional data on their efficacy were unnecessary before moving to systematically integrate these technologies into schools." The authors note that societal forces may become more powerful than data developed by a scientific community. They also report on a comment made in a report of the President's Committee of Advisors on Science and Technology (PCAST, 1997) "The Panel does not, however, recommend that the deployment of technology within America's schools be deferred pending the completion of a major program of experimental research." (p. 131).

What counts as research? There is little doubt that we can't afford to make sound recommendations for digital literacy instructional practices based on anecdotal evidence alone or on ungrounded inclinations that may be more driven by opinions than it is by objective observation. However, we also can't afford to wait the typical 10-15 year cycle it takes for research results to filter into the classroom. It is crucial that we adopt new notions of what counts as research and who is qualified to conduct research. University and classroom teacher collaborative research partnerships, presented and discussed in a wider Web community of educators, is one possibility worthy of consideration. Teacher Action Research projects that coincide with Staff Development and accountability for dissemination of results may also be a productive means of discovering crucial insights related to digital literacy instruction.

What types of research questions may help us realize a vision of a digitally literacy instructional program?* Research that is both quantitative and qualitative is needed. Research that is conducted over the short term, and longitudinally is needed. The following types of research questions may help begin to articulate an agenda for inquiries of various types:

(1) Research questions about digital literacy instruction:

- How should we teach children to navigate the Web?
- How do teachers integrate computer-related technologies effectively into their classroom literacy curriculum?
- What are effective ways to prepare preservice teachers to enact effective digital literacy instruction?
- How should classrooms be designed, arranged, and managed to make best use of digital literacy equipment?
- What are effective ways to conduct staff development on computer literacy-related instruction for professional teachers during staff development?
- What should we expect across a developmental digital literacy continuum from kindergarten through 12th-grade?

(2) Research questions about digital literacy meaning making processes:

- How are various digital genres written and read?
- What is the interaction between cognition and features of digital literacy programs?
- How do young children make sense of multimedia symbol systems with and across digital documents?
- What features of digital texts are most supportive of various children's literacy needs and why?

- What are children's opportunities to construct literacy knowledge with digital tool kits?
- How can we assess children's comprehension of digital documents such as hypertext?
- How should we design and conduct effective digital literacy assessment?
- What is the cognitive relationship between reading alphabet-based symbols and reading multimedia symbols?
- What new literacies emerge with the use of internet technologies for reading and language arts?

CONCLUDING COMMENTS: READY OR NOT, HERE IT COMES!

In writing this paper I have resisted the advice of some in the field to discuss computer-related education in the near future in America as an activity that will occur outside of the walls of a classroom. By doing so, I do not mean to ignore the likelihood that schooling may be so reconceptualized and transformed in the long range that it will no longer occur in classrooms. On the contrary, I suspect many viable alternative forms for on-line approaches to literacy education will occur as the decades unfold and as society changes to embrace technological innovations. However, I strongly suspect that the institution called school will survive well into the 21st century and that teachers will continue to play a central role in children's digital literacy development.

Speculation about the longer term view of literacy education suggests to me that the time will one day come when every child in an instructional setting will have a digitally produced Personal Learning Assistant (PLAyer) who will be designed to respond to the literacy instructional needs of the child. Entire instructional rooms will be intelligent, in the sense that they will be equipped with technology that is intuitive and responsive to children's gestures, touches, and voices through a multiplicity of intuitive interface structures. Computer technologies will recognize and transform spoken words into any symbol system the communicator wishes to use to express particular ideas for particular purposes (Labbo, in press b). While these thoughts of the future are engaging and entertaining, the technological strides needed for such a longer term vision to become reality are substantial and are not likely to occur within the first decades of the 2000s.

In closing, whether we are ready for the paradigm shift about literacy education that is sure to occur, the societal forces for integrating digital literacies into the local workplace, popular culture, and global marketplace are upon us. It is up to us to figure out how to best prepare for the inevitable changes that are sweeping the informational internet across our nation, but are making only soft inroads into classrooms. As long as we have institutions in America called public schools, teachers will be given the mandate to prepare every student who enters their classrooms to be able to act as literate beings in the life of American society. Between the near term and the long term, computers stand to foster students' development of both traditional and digital literacy; however, we have many questions to answer and many cautions to consider as we formulate a vision for best computer-related literacy practices. As a final thought, I suggest that the banner posted over the state of computer literacy-related use in classrooms of today and of the near future is not one that reads, *Under Construction* , but one that reads, *Under A State Of Jumbled Construction*. Like Dorothy and her companions in the Land of Oz, making our vision a reality will take great deal of intelligence, heart, and courage.

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*Contributions of questions for future research were made by
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White Papers

Intersection of Technology Trends

By Mary O'Hara Deverauex

Emerging Technologies	Technologies Intersection Map	Technologies Map
(619k)	(270k)	(354k)

Introduction | Forum Report | Forum White Papers | Forum on Technology in Education | Emerging Priorities | Comment Here | Technology Plan

Page last updated on 05/2/00 (dkb)

- Your Comments
- Introduction
- Forum Report
- White Papers
- Forum on Technology in Education
- Emerging Priorities
- '96 ET Plan

AGENDA

DAY ONE

8:30
- Welcome and orientation
- Opening remarks
- Emerging technologies: A map of the horizon *Presentation by Mary O'Hara Devereaux*
- Technology in K-12 education: Envisioning a new future *Presentation by David Thornburg*

11:00 BREAK

11:15
- Extracurriculars as the curriculum:A vision of education for the 21st century *Presentation by Roger Schank*

12:15
- LUNCH

1:15
- Technology and content presentation white paper presentations (Part 1)

Social Studies Presentation by Randy Bass and Roy Rosenzweig
Science Presentation by Steven Rakow
Mathematics Presentation by Andee Rubin

3:15
- BREAK
- Synthesis of emerging trends, assumptions and opportunities for leadership

5:30
- Wrap-up and orientation to tomorrow's work

DAY TWO

9:00
- Orientation to day 2
- Technology and content whitepaper presentations (Part 2)

Art Presentation by Joan Assey
Language Arts Presentation by Linda Labbo

10:30 BREAK

10:45 Envisioning the Future: Exploring desired future states of education and technology

12:30 *LUNCH*
with U.S. Congressman John B. Larson

11:15 Synthesis of emerging trends, assumptions, leadership opportunities:*Toward Draft National Goals*

3:00 *BREAK*

3:15 Prioritization and refinement of draft goals and strategies

4:30 Wrap-up and next steps

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Forum on Technology in Education: Envisioning the Future

Participant Biographies

JOAN ASSEY

Dr. Assey is a professional educator, currently serving as the Technology Advisor for Education in the Office of the Governor in Columbia, South Carolina. Previously she was Director of Information Technology for Richland School District Two for five years. Dr. Assey was named Administrator of the Year (1994) by the South Carolina Association for School Administrators and was recognized by South Carolina Commission on Women for her leadership and contributions to African American Studies. She also was named Southeastern Administrator of the Year by the National Art Education Association and Technology Educator of the Year by the South Carolina Association for Education Technology. Dr. Assey has been a grant recipient and has served as a panelist for the National Endowment for the Humanities, and has served on panels for the South Carolina Commission on Higher Education (Centers for Excellence), and the South Carolina Arts in Education Target 2000 Arts Grants. She served as chair of the South Carolina Humanities Council and is a member of the Technology Public Education Advisory Group and South Carolina Arts Commission's education steering committee. In addition, Dr. Assey is a past board member of the Columbia City Ballet, and the Columbia Music Festival. She received B.A., M.Ed., and Ed.D. degrees from the University of South Carolina at Columbia.

RANDALL BASS

Randy Bass is Executive Director of the Center for New Designs in Learning and Scholarship (CNDLS) at Georgetown University, a campus-wide center supporting faculty work in new learning and research environments. He is also the Director of the American Studies Crossroads Project, an international project on technology and education sponsored by the American Studies Association, with major funding by the US Department of Education's Fund for the Improvement of Postsecondary Education and the Annenberg/CPB Project. In conjunction with the Crossroads Project, Bass is the supervising editor of Engines of Inquiry: A Practical Guide for Using Technology to Teach American Studies, and executive producer of the companion video, Engines of Inquiry: A Video Tour of Learning and Technology in American Culture Studies. He is a co-leader of the NEH-funded "New Media Classroom Project: Building a National Conversation on Narrative Inquiry and Technology," in conjunction with the American Social History Project/Center for Media and Learning (at the CUNY Graduate Center). He is also the Electronic Resources Editor for the Heath Anthology of American Literature (third edition, Paul Lauter, ed.), and the founder of T-AMLIT, the "Teaching the American Literatures discussion list." He has been working with educational technology since 1986 and has directed or co-designed a number of electronic projects; among other current projects he has served as a facilitator and consultant to the "American Memory Fellows Program" of the Library of Congress. He is also a senior associate with the Teaching, Learning, and Technology Group, with the American Association for Higher Education. For 1998-99, he served as a Pew Scholar and Carnegie Fellow in conjunction with the Pew-funded Carnegie Teaching Academy, for the Carnegie Foundation for the Advancement of Teaching. In 1999, he was awarded the EDUCAUSE Medal for Outstanding Achievement in Information Technology and Undergraduate Education, in behalf of the American Studies Association. Bass is Associate Professor of English and a member of the American Studies Committee at Georgetown University. In 1993-4 he served as the American Studies Keck Foundation Faculty Fellow at Georgetown. He is the author of Border Texts: Cultural Readings for Contemporary Writers (Houghton Mifflin, 1998); and co-editor of Intentional Media: the Crossroads Conversations on Learning and Technology in the American Culture and History Classroom (Works & Days, forthcoming, Fall 1999).

JIM BLACKABY

In October, Jim Blackaby accepted the position of Director of Internet Strategies and Information Services at Mystic Seaport in Mystic, CT. Prior to that as Senior Systems Analyst at the Walker Art Center in Minneapolis he worked on several projects, but primarily Arts ConnectEd, an award-winning integrated access system for the intellectual and educational resources of the Walker and the Minneapolis Institute of Arts. He has also served as Senior Systems Developer at the United States Holocaust Museum working on the Student Outreach Project, the reinstallation of the Learning Center, and related projects. From 1990 to 1996, Mr. Blackaby worked as an independent consultant in museum information systems, web applications for museums, and multi-media projects. His special areas of interest have included the integration of all the resources museums manage -- collection information, educational material, library and archives materials, and digital assets. He has worked with the Guggenheim, the L.A. County Museum of Art, the Anchorage Museum of History and Art, the National Museum of African Art, the Hirshhorn Museum and Sculpture Garden, the Society for the Preservation of New England Antiquities, and the National Trust. From 1980 to 1989, Mr. Blackaby was Curator of the Mercer and Fonthill Museums in Doylestown, PA. Prior to that, he taught on secondary level and in university. He continues to teach both distance and on-site courses and workshops at the University of Victoria in Victoria, BC.

LARRY CUBAN

Larry Cuban is a Professor of Education at Stanford University. His background in the field of education prior to becoming a professor includes 14 years of teaching high school social studies in ghetto schools, directing a teacher education program that prepared returning Peace Corps volunteers to teach in inner-city schools, and serving seven years as a district superintendent. His major research interests focus on the history of curriculum and instruction, educational leadership, school reform and the uses of technology in classrooms. His books include: How Scholars Trumped Teachers: The Paradox of Constancy and Change in University Curriculum, Research, and Teaching, 1890-1990 (1999);Tinkering Towards Utopia (with David Tyack), 1995; The

Managerial Imperative: The Practice of Leadership in Schools (1988); Teachers and Machines: The Use of Classroom Technology Since 1920 (1986); How Teachers Taught, 1890-1980 (1984); Urban School Chiefs Under Fire (1976); To Make a Difference: Teaching in the Inner City (1970).

MARY O'HARA DEVEREAUX

Mary has consulted, led research studies, managed large development projects, written, and lectured in health care, global business, and emerging technologies for governments, industry, health systems and providers, universities, and a variety of nonprofit agencies and small community groups. She has worked in 25 countries in North and South America, Asia, Africa, Europe, and the Pacific Basin. Mary divides her work between the economically developed and developing countries, in an effort to contribute to more equitable global development. Mary specializes in providing business organizations with understanding and forecasting of the major issues and trends affecting global network-style organizations in the areas of culture, emerging technologies, and the management of global, distributed, and cross-cultural teams. She combines consultative strategic planning with survey research, using case studies, opinion leader interviews, policy analysis, and synthesis of other cutting-edge research to help clients select the best choices for creating the future they envision. Both a psychologist and primary health care specialist, Mary has a B.S from the University of Michigan, an M.S. and an M.H.S from the University of California, and a Ph.D. from The Fielding Institute, Santa Barbara, California.

DONALD ELY

Currently, Don Ely is Special Assistant to the Director or the ERIC Clearinghouse on Information & Technology, which he founded in 1977. He also serves as a Visiting Professor at Florida State University where he works in the area of Distance Education. For the past 20 years he has been an Adjunct Professor at the University of Twente in The Netherlands. He was the Program Director for Dissemination at the National Science Foundation during 1993-1994. He has held three Fulbright appointments in Chile and Peru. Research interests are in the implementation of educational technology innovations, cross-cultural communication, and trends in the field of educational technology.

RAYMOND FARLEY

In May 1995, Ray Farley was named "Educator-Administrator of the Year" by *New Jersey Monthly* magazine, and in October, the 1996 "Superintendent of the Year" for New Jersey. In April 1998, Mr. Farley was named Medal Laureate, Holder of the Information Technology Innovation Distinction, Smithsonian Institution, Washington, DC. His school district, Hunterdon Central, has been awarded New Jersey's highest honor, the "Star School" award three times, and has also been the recipient of several national awards, including Business Week magazine's "School of the Year" for innovation in the age of technology for 1995, the "Blue Ribbon" School of Excellence award for 1996 from the U.S. Department of Education, Redbook magazine's 1996 award of Best High Schools in America, the Smithsonian Award for Information Technology Innovation, 1998, and the National School Library Media Program award, 1998. Presently, Mr. Farley is working on a cyberspace regionalization project, which has the personal endorsement of New Jersey's Governor Whitman, and is being financed through major grants from the AT&T Foundation and Compaq Computer. The scope of the project includes a university serving as mentor and trainer for the teachers and students, major corporations supplying needed resources, and telecommunications partners both in the United States and Asia.

WELLESLEY "ROB" FOSHAY

Dr. Foshay is responsible for the definition of quality standards and methodology across all TRO product lines, internal training in support of the methodology, product design planning, and quality standards management and assurance. Dr. Foshay also is responsible for the evaluation of the instructional effectiveness of PLATO products. He consults with clients in support of TRO's sales, marketing, and support efforts and is a frequent spokesman for TRO at professional conferences. Prior to joining TRO, Dr. Foshay was the Director of Product Quality Assurance, Standards and Training of Applied Learning International, Inc. (ALI). Prior to an eight-year tenure with Applied Learning International, Inc., Dr. Foshay served on the faculty of the University of Illinois - Champaign. While at ALI, he served as adjunct faculty at Governors State University. He began his career as a high school social studies teacher and district media coordinator. A nationally recognized speaker and writer for many academic and professional groups on instructional design and human performance technology, Dr. Foshay has published over 50 major journal articles and book chapters. He currently serves on the editorial boards of two refereed journals, Educational Technology Research and Development Journal, and Performance Improvement Quarterly. Dr. Foshay's training includes a Ph.D. in Instructional Development from Indiana University, a M.A. in Social Studies Education from Columbia University Teachers College, and a B.A. in Political Science from Oberlin College.

CHARLES "CHUCK" HOUSE

Chuck House joined Dialogic in late 1995, as President of Spectron MicroSystems, a wholly-owned subsidiary in Santa Barbara, CA. His present role as Executive Vice President for Research was defined in spring 1999. Dialogic research is focused on SSP and the VIVID (Video Integrated with Voice Integrated with Data) toolkit, especially voice-enabled applications and technologies. “Distance learning” and “corner conference room” enhancements based on IP technologies are foremost in the application focus. His current interests focus heavily on issues of communications modalities, especially graphical and multi-media literacy; and societal issues raised or illuminated with computing technology, such as “reality processing” questions of public safety and ethical behaviors. He and Dialogic have been instrumental in establishing the new Center for Information Technologies and Society at the

University of California, Santa Barbara, and he serves as Advisory Chairman. House served as ACM President, an IEEE Vice-President of Publications, and a Computer Museum and History Center Board Member, as well as a Founding Board Member and long-term instructor with NTU (National Technological University, graduate level satellite-based teaching). He created and taught Communications and Society at Stanford under NSF grant from 1984-1989. He spent many years at Hewlett-Packard in a variety of development roles, and he has been involved with numerous start-up companies as well.

THOMAS KALIL

Thomas A. Kalil is currently a senior director to the National Economic Council with responsibility for science and technology issues. The NEC is a White House organization created by President Clinton to coordinate economic policy. In addition to his role in shaping the Administration's national information infrastructure agenda, he is also the U.S. National Coordinator for the G-7 Global Information Society pilot projects. Tom served as an advisor to the Clinton-Gore campaign on technology and competitiveness issues, and helped organize the Little Rock Economic Summit. Prior to that, he was a trade specialist at the Washington offices of Dewey Ballantine, where he represented the Semiconductor Industry Association on U.S.-Japan trade issues and technology policy. He received a B.A. in political science and international economics from the University of Wisconsin at Madison, and completed graduate work at the Fletcher School of Law and Diplomacy. He is the author of articles on nuclear strategy, U.S.-Japan trade negotiation, U.S.-Japan cooperation in science and technology, and the NII. Tom is a member of the Council on Foreign Relations and the Association for Computing Machinery.

LINDA LABBO

Dr. Labbo received her Ph.D. from the University of Texas in Austin. She is currently an Associate Professor in the Department of Reading Education at The University of Georgia where she conducts research on young children's computer-related literacy development and culturally-responsive curriculum & instruction. From 1993-1997 she served as a Principal Investigator for several technology-related research and development projects funded through the National Reading Research Center by the Office of Educational Research and Improvement, U.S. Office of Education. She is currently a co-primary principal investigator for a technology-related grant funded by The Spencer Foundation. As a Kezai Koho Center Fellow, she wrote curriculum materials and conducted research in 1997 on technology in Japan. She has presented over 70 scholarly papers at conferences in the USA, Norway, England, and South Africa and has been an invited speaker for the Harvard Graduate School of Education Graduate Studies Colloquium. Author of 47 publications, including a co-edited book titled Literacy for the 21st century: Technological transformations in a post-typographic world (1998), which won a American Library Association Award as an Outstanding Academic Book of the year. Her articles have been published in premiere literacy education journals such as, Reading Research Quarterly, Journal of Literacy Research, The Reading Teacher, Language Arts, and The Peabody Journal of Education. Her creative contributions include an interactive case-based instructional resource CD-ROM and an instructional resource video titled, "Incorporating the computer into the classroom: A kindergarten case study". She is past president of the Computers in Reading Special Interest Group of the International Reading Association and a current section editor for Reading On-Line, the on-line journal for the International Reading Association.

CONGRESSMAN JOHN B. LARSON

U.S. Congressman John B. Larson began his first term in office on January 6, 1999. He brings to Washington many significant legislative accomplishments from his twelve year tenure in the Connecticut state Senate, eight as President Pro Tempore. He is credited with establishing the nation's first family and medical leave legislation, advocating comprehensive educational programs, leading efforts to clean up Long Island Sound, and sponsoring the first conference on economic diversity to help defense industries adjust to federal cutbacks. He also created and chaired Connect '96, a project that brought the Internet into Connecticut classrooms and libraries. Under his direction, 4,000 volunteers were mobilized into action to make this communications link a reality. Understanding the many and varied strains placed on families, he worked with Dr. Ed Zigler, the creator of Head Start, to develop Family Resource Centers in public schools. These schools of the 21st century offer extensive and coordinated childcare and family support services. As a member of Congress, Larson will continue to focus on education, technology, and the economic issues he has worked tirelessly on during his over twenty years of government service at the state and local level. He has been named to two Congressional committees: Science and Armed Services. Specifically, he is on the Science Subcommittees: Basic Research and Space and Aeronautics, and the Armed Services Subcommittees: Military Research and Development and Military Personnel. In addition, he is a member of the Congressional Law Enforcement Caucus, the Congressional Missing and Exploited Children's Caucus, the Congressional Native American Caucus, the Congressional Fire Services Caucus, the Friends of Ireland Caucus, Committee for Irish Affairs, Education Task Force, Livable Communities Task Force, Congressional Arts Caucus, and the New Democrat Coalition. Larson began his career as a high school teacher and started his own insurance company prior to joining the state Senate. He is a graduate of Central Connecticut State University and a Senior Fellow at the Yale Bush Center for Child Development and Social Policy. A lifelong resident of East Hartford, he and his wife Leslie have two daughters and one son.

ALAN LESGOLD

Alan Lesgold received his Ph.D. in psychology from Stanford University in 1971 and joined LRDC and the Department of Psychology of the University of Pittsburgh that same year. He is a fellow of the Divisions of Experimental, Applied, and Educational Psychology of the American Psychological Association, a fellow of the American Psychological Society, and a past president of the Society for Computers in Psychology. He also served as co-editor of Machine-Mediated Learning, on the editorial boards of several research periodicals, and on advisory panels for several educational research and development organizations. He was Secretary/Treasurer of the Cognitive Science Society from 1988 to 1997. In 1995, he was awarded the Educom Medal by Educom and the American Psychological Association for contributions to educational technology. In September 1999, the Open University of the Netherlands awarded him an honorary doctorate. Lesgold served on the National Research Council Board on Testing and Assessment from 1993 through 1998 and chaired the Board's Roundtable on Schooling, Work, and Assessment. He also served on two Congressional Office of Technology Assessment advisory panels and was the chair of the Visiting Panel on Research of Educational Testing Service. Lesgold and colleagues developed a technology of intelligently coached learning by doing over the period from 1986 to the present, in partnerships with the U.S. Air Force, US WEST, and Intel Corporation. More recently, he and his colleagues also developed a technology for supporting rich collaborative engagement with complex issues and complex bodies of knowledge. This work is now being applied to professional development as part of LRDC's Institute for Learning, a partnership with urban school systems for standards-based school system restructuring.

BARBARA MEANS

Barbara Means is Co-Director of the Center for Technology in Learning at SRI International. Dr. Means is an educational psychologist whose research focuses on ways in which technology can support students' learning of advanced skills and the revitalization of classrooms and schools She has directed numerous research projects concerned with the design, implementation, and assessment of technology-enabled solutions to critical issues in school reform. Her current projects include a U.S. Department of Education grant to support development of a research agenda for educational technology, studies of technology use in urban high schools, and evaluation of GLOBE, a worldwide Internet-supported environmental science and education project. Dr. Means is also co-leading (with John Bransford) the assessment research team of the Center for Innovative Learning Technologies, an NSF-funded center directed toward improving K-14 science and mathematics education. Her published works include the books *Technology and Education Reform, Teaching Advanced Skills to At-Risk Students* (with Carol Chelemer and Michael Knapp), and *Comparative Studies of How People Think* (with Michael Cole). Dr. Means recently served on the National Academy of Sciences' Committee on Developments in the Science of Learning and is currently a member of the Academy's Board on Testing and Assessment. Dr. Means earned her Ph.D. in education and intellectual development at the University of California, Berkeley and her bachelor's degree in psychology from Stanford University.

KATRINA MILLER

Katrina Miller is a fearless senior at Powell High School in a suburb in Knoxville, Tennessee. She is currently the national Technology Students Association's (TSA) student president, and has served as an officer for the TSA for the past three years. While serving as the TSA student president, Ms. Miller has had many speaking engagements including attending the board of directors meeting for TSA, a symposium for technology education teachers, a vocational advisory council meeting, several national and state leadership conferences, as well as many other speaking engagements. She has also been traveling to many different schools helping with their technology education programs and starting TSA chapters. Ms. Miller also actively participates in her school's mock trial team, of which she has been a member and leader for the past seven years. In addition, she is active in the school concert choir and the BETA club, which is a service organization. Ms. Miller is planning to major in technology education with a minor in speech communications when she enters college in the Fall of 2000. She hopes to obtain her Masters degree, and teach for a few years while starting a business in leadership development and motivational speaking.

STEVE J. RAKOW

Dr. Rakow is a Professor of Science Education and the Program Chair for Curriculum and Instruction at the University of Houston-Clear Lake. He received his doctorate in Curriculum and Instruction from the University of Minnesota in 1984. There he had the opportunity to work on two major projects--the Computer Literacy Instructional Modules (CLIM) Project through Minnesota Educational Computing Consortium and the 1981/82 national assessment study in science. It was this latter project that sparked his research interests in the status of the science education for minority students. At the University of Houston-Clear Lake, Steve specializes in elementary science education. He was the 1989 recipient of the Rebecca Sparks award from the Texas Council for Elementary Science for outstanding contributions to elementary science teaching in Texas. Steve has written more than 90 journal articles, as well as numerous chapters and books. For five years Steve served as the Editor of *Science Scope* , the National Science Teachers Association's journal for middle level teachers. From June 1, 1998 to May 31, 1999, Steve held the role of President of the National Science Teachers Association (NSTA). With over 53,000 members, NSTA is the world's largest association dedicated to the improvement of science education. Currently Steve is the Retiring President of NSTA and a member of the Board of Directors and the Executive Committee of NSTA.

DIANE REED

Diane is presently serving as the "Technology Teacher in Residence" in the office of Educational Technology in the U. S. Department of Education in Washington, DC. Before going on loan to the U. S. Department of Education, Diane was with Fairfax County Public Schools in Fairfax, Virginia where she was a classroom teacher for 19 years. For four years, she worked in the Department of Instructional Services, Division of Technology Services, where she was responsible for the design and delivery of technology and technology-related training programs for instructional and administrative staff. She collaborated in the design of training models to meet a variety of specific needs, and assisted teachers and administrators in the implementation of technology integration into the instructional program. Diane chaired and facilitated the taskforce on teacher technology certification in 1997-1998. This taskforce has put into place one of the most comprehensive programs in the Commonwealth of Virginia to certify in-service teachers in the Virginia Technology Standards for Instructional Personnel

Diane also serves as an adjunct instructor for the University of Virginia teaching a course - CaseNET: Using Technology to Solve Problems in Schools. This course focuses on the latest research in instructional technology and using a case-based format to show how technology can improve teaching and learning. In addition, Diane is pursuing her doctorate at the University of Virginia, Curry School of Education. Diane is the immediate past-president of the Virginia Society for Technology in Education (VSTE), Virginia's ISTE affiliate.

LINDA G. ROBERTS

Linda G. Roberts is Director of the Office of Educational Technology and Special Adviser to the Secretary of the U.S. Department of Education. The November 1998 Smithsonian Magazine cites Roberts' "championship thinking" and says she is "America's advocate for educational technology at the highest levels of government." Dr. Roberts coordinates the Department's technology programs and plays a key role in developing the Clinton Administration's Educational Technology Initiative. Roberts steered the development of the Technology Innovation Challenge Grants, the Technology Literacy Challenge Fund, the Regional Technology in Education Consortia, and the new

Technology Teacher Training Program, a total of $698 million in FY99 budget. As Senior Adviser on Technology, Dr. Roberts represents the Secretary on the Vice President's National Information Infrastructure Task Force, and other interagency efforts. She is also a member of the White House educational technology working group. Roberts' career started in 1962 when she was an elementary classroom teacher and reading specialist in Ithaca, NY and Brookline, MA. She later taught elementary, secondary and adult reading programs in Oak Ridge, TN and then joined the faculties of the University of Tennessee and Lincoln Memorial University. Prior to joining the Department, Roberts was a Project Director and Senior Associate with the Congressional Office of Technology Assessment (OTA), where she headed up three major assessments on educational technology: *Power on! New Tools for Teaching and Learning, Linking for Learning: A New Course for Education, and Adult Literacy and New Technologies: Learning for a Lifetime.* Roberts holds a B.S. from Cornell University (1962), an Ed.M. from Harvard University (1963), and an Ed.D. from the University of Tennessee (1973).

ROY ROSENZWEIG

Roy Rosenzweig is CAS Distinguished Professor of History at George Mason University, where he also heads the Center on History and New Media (CHNM). He holds a Ph.D. degree in History from Harvard University (1978) and also studied at Columbia University in New York and Cambridge University in England. He is the co-author, with Elizabeth Blackmar, of *The Park and the People: A History of Central Park* , which won several awards including the 1993 Historic Preservation Book Award and the 1993 Urban History Association Prize for Best Book on North American Urban History. His other books include *Eight Hours for What We Will: Workers and Leisure in an Industrial City, 1870-1920* (Cambridge University Press) and edited volumes on history museums (*History Museums in the United States: A Critical Assessment*), history and the public (*Presenting the Past: Essays on History and the Public*), history teaching (*Experiments in History Teaching*), and oral history (*Government and the Arts in 1930s America*). He is the author of numerous scholarly articles as well as articles and reviews in such publications as *The Nation, The New York Times Book Review* , and the *Times Literary Supplement*. His multimedia CD-ROM, *Who Built America? From the Centennial Celebration of 1876 to* *the Great War of 1914* (Voyager), with Steve Brier and Joshua Brown was a finalist in the first Interactive Media Festival and won the James Harvey Robinson Prize of the American Historical Association for an "outstanding contribution to the teaching and learning of history." A sequel is forthcoming early in 2000. As founder and director of CHNM, he is involved in a number of different new media projects including the Web site, History Matters: The U.S. Survey Course on the Web, and forthcoming CD-ROM and Web site on the French Revolution. He has been the recipient of a Guggenheim Fellowship and has lectured in Australia as a Fulbright Professor. He is also the co-producer of a historical documentary film, *Mission Hill and the Miracle of Boston*. His most recent book (co-authored with David Thelen) is *The Presence of the Past: Popular Uses of History in American Life* (Columbia University Press), which has won prizes from the Center for Historic Preservation and the American Association for State and Local History.

ANDEE RUBIN

Andee Rubin has worked extensively for over 25 years in the fields of mathematics and language arts education, focusing on the role of technology in both areas, on the evolution of students' mathematical concepts and on professional development in mathematics and technology for elementary teachers. She designed several pioneering pieces of educational software, including QUILL (writing environments for elementary school), ELASTIC (statistics software for high school) and CamMotion (digitized video tools for teaching advanced mathematical concepts.) Most recently, she was a major author of the NSF-funded K-5 mathematics curriculum *Investigations in Number, Data, and Space* , focusing in particular on data analysis concepts. She was also a developer of professional development materials that accompany the curriculum and led national workshops that used these materials. In the fall of 1997, she was a math content guide for a series of nationally broadcast interactive teacher development workshops entitled *What's the Big Idea?* funded by the Annenberg Foundation. At TERC, where she has worked for 10 years, she is currently directing a project that is investigating educational computer games that teach math and that are appealing to girls. She received her S.M. and E.E. from MIT in computer science and artificial intelligence

NORA SABELLI

Dr. Sabelli received a Ph.D. in Theoretical Chemistry from the University of Buenos Aires, Argentina for research performed at the University of Chicago. She is currently Senior Program Director in the Directorate for Education and Human Resources at the National Science Foundation, and was last year on detail at the Office of Science and Technology Policy on issues of research, technology, and education. She has worked at NSF on the agency-wide Research on Learning and Intelligent Systems; the Research on Education, Policy and Practice Program and was a member the NSF-wide Knowledge and Distributed Intelligence implementation group. After a career as a research scientist and faculty member, she is focusing on helping understand how to provide quality science, mathematics and technology education for all students, reflective of current scientific advances and technology opportunities.

ROGER SCHANK

Dr. Schank is the Chairman and Technology Officer for Cognitive Arts and has been the Director of the Institute for the Learning Sciences since its founding in 1989. He holds three faculty appointments at Northwestern University as John Evans Professor of Computer Science, Education, and Psychology. Previously, he was Professor of Computer Science and Psychology at Yale University and Director of the Yale Artificial Intelligence Project. He was also a visiting professor at the University of Paris VII, a faculty member at Stanford University, and research fellow at the Institute for Semantics and Cognition in Switzerland. In addition, Dr. Schank is a fellow of the AAAI, the founder of the Cognitive Science Society, and co-founder of the Journal of Cognitive Science. He holds a Ph.D. in Linguistics from the University of Texas. One of the world's leading Artificial Intelligence researchers, Dr. Schank is the author of more than 125 articles and publications. His books include: *Dynamic Memory: A Theory of Learning in Computers and People, Tell Me a Story: A New Look at Real and Artificial Memory, The Connoisseur's Guide to the Mind,* and *Engines for Education*. His newest book is *Virtual Learning: A Revolutionary Approach to Building a Highly Skilled Workforce.*

KATHLEEN SCHROCK

Kathleen Beck Schrock is currently the District Technology Department Head for the Dennis-Yarmouth Regional School District on Cape Cod, MA. A large part of her job is involved with integrating technology into the curriculum in all areas and at all grade levels. Previously a library media specialist, she is very interested in search strategies, evaluation of Internet information, copyright issues, and use of the computer as a tool to support instruction. She is the creator and maintainer of Kathy Schrock's Guide for Educators an educational portal that has been on the Web since June, 1995.

MARSHALL "MIKE" SMITH

As Acting Deputy Secretary of the U.S. Department of Education, Marshall S. Smith serves as both the chief operating officer and principal advisor to the Secretary on Federal education policy and budget issues. Smith was named Acting Deputy Secretary in August, 1996. As the Department's chief operation officer, Smith sits on the President's Management Council and oversees day-to-day management of the Department. In addition, he is charged with the development of the Department's first ever strategic plan and with other "reinventing government" efforts to streamline management and operations. As principal policy and budget advisor, Smith also directs the development of the Department's policy and budget each year--combining President Clinton's commitment to education with Administration efforts to reinvent and streamline Government. In addition, he leads the Department's efforts to respond to the President's "Call to Action for American Education" which includes ensuring equal access to education and promoting education excellence for all students across the nation. Prior to being named Acting Deputy Secretary, Smith was the Under Secretary. Upon his appointment to be the Acting Deputy Secretary, Secretary Riley stated that "Mike Smith has been one of the most valuable members of the new Administration. He has played a leading role in developing our budget request and our landmark reform proposal, the Goals 2000: Educate America Act", as well as the Student Loan Reform Act which created the Direct Student Loan Program. As Under Secretary, Smith was a key player in defining an Administration agenda that addressed the national need to raise educational achievement for all students and increase their opportunities to pursue postsecondary education and lifelong learning. He directed the development of major legislative initiatives such as the Goal 2000: Educate American education were passed with strong bipartisan support in Congress. As Under Secretary, Smith defined a new federal role in American education--one in which the federal government serves as a supportive partner to local districts and states as they seek to carry out their own reforms in education. He advanced the idea all students can benefit from higher standards and challenging curricula. He stressed that intensive, sustained professional development of teacher and principals is essential to successful education reform. He strongly advocated the idea of flexibility for schools and teachers so that they can improve teaching and learning, couples with greater accountability for student performance. And he emphasized the importance of strong partnerships among parents, schools, communities, higher education, and business. Smith's published writings cover a wide range of issues, including desegregation, early childhood programs, effective schools, and the effect of federal policies on state and local practice. His recent interests have focused on the education of children at risk of school failure, state school reform, and national trends in curriculum development. Prior to his appointment as Under Secretary, Smith was a professor of education and Dean of the Graduate School of Education at Stanford University. Previously, he was an associate professor at Harvard Graduate School of Education and a Professor at the University of Wisconsin at Madison, where he served as the Director of the Wisconsin Center for Education Research. Smith earn both a master's (1963) and a doctoral (1970) degree in measurement and statistics from the Harvard Graduate School of Education. Smith has held several policy positions in the federal government, prior to his current post, including serving as Chief of Staff to the first Secretary of Education. He has served as an advisor to the National Education Goals panel and was a member of the National Council of Education Standards and Testing. He is currently a member of the National Academy of Education.

DAVID THORNBURG

Director of the Thornburg Center and Senior Fellow of the Congressional Institute for the Future, Dr. Thornburg consults on the uses of technology in education for the Federal governments of the United States and Brazil, and speaks to over 100,000 educators a year, worldwide. David has received numerous awards for his work, including being elected one of twenty "Pioneers in Educational Technology" by ISTE, and being the recipient of the Golden and Platinum Disk Awards from Computer Using Educators. In addition to his consulting and speaking engagements, he is the author of several books on educational technology and the producer of a monthly PBS Internet radio program based on his work. Prior to working in education, David was one of the first members of the Xerox Palo Alto Research Center and the co-founder of two small companies in Silicon Valley. He currently splits his residence between San Francisco, California and Recife, Brazil.

TONYA VANDERGRIFF

Tonya Vandergriff teaches Technology Education at Powell High School in Knoxville, Tennessee. She began her interest in the field of Technology Education/Industrial Arts when she was in the seventh grade. Since that time, she has made it her lifelong pursuit to be involved in the growth and development of Technology Education. While in High School, Vandergriff served the Technology Student Association as the National Secretary and the National President. She received both her bachelor's and master's degrees from the University of Tennessee - Knoxville. Presently, she is the National Advisor to the National Officers of the Technology Student Association and provides Leadership training to the association.

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Forum on Technology in Education: Envisioning the Future

Participant Affiliations

TONY AMATO
Hartford Public Schools
Hartford, CT

JOAN ASSEY
Office of the Governor-
South Carolina

RANDALL BASS
Georgetown University

JIM BLACKABY
Mystic Seaport
The Museum of America and the Sea

LARRY CUBAN
Stanford University

CONGRESSMAN JOHN LARSON
D—Connecticut

ALAN LESGOLD
University of Pittsburgh

BARBARA MEANS
SRI International

KATRINA MILLER
National Technology
Student Association

STEVEN RAKOW
University of Houston-
Clear Lake

MARY O'HARA DEVEREAUX
Institute for the Future

DONALD ELY
Syracuse University

RAYMOND FARLEY
Hunterdon Central
Regional High School
Flemington, NJ

WELLESLEY "ROB" FOSHAY
TRO Learning, Inc.

CHARLES "CHUCK" HOUSE
Intel Dialogic Division

THOMAS KALIL
National Economic Council

HENRY KELLY
Executive Office of the
President

JIM KOHLENBERGER
Office of the Vice President

DIANE REED
U.S. Department of
Education-Technology
Teacher in Residence

LINDA ROBERTS
U.S. Department of
Education

ROY ROSENZWEIG
George Mason University

ANDEE RUBIN
TERC

NORA SABELLI
National Science
Foundation

ROGER SCHANK
Northwestern University

KATHLEEN SCHROCK
Dennis-Yarmouth
Regional School District
South Yarmouth, MA

MARSHALL "MIKE" SMITH
U.S. Department of
Education

LINDA LABBO
The University of Georgia

DAVID THORNBURG
The Thornburg Center

TONYA VANDERGRIFF
Powell High School
Knoxville, TN

Introduction | Forum Report | Forum White Papers | **Forum on Technology in Education** | Emerging Priorities | Comment Here | 1996 National Educational Technology Plan

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Page last updated on 04/7/00 (cdd)

- Your Comments
- Introduction
- Forum Report
- White Papers
- Forum on Technology in Education
- Emerging Priorities
- '96 ET Plan

Emerging Priorities

The Forum on the Future of Technology in Education: Envisioning the Future concluded with the identification of emerging priorities.

All students and teachers will have universal access to effective information technology in their classsrooms, schools, communities, and homes.

Much of the promise of the use of technology in education, including the notion of fostering learning anytime anywhere, hinges on the universal availability of learning tools for students and teachers and on their effective use. In addressing this issue, it is important to pay attention to individual learner characteristics and needs, as well as the social context of using technology.

All teachers will effectively use technology

There is universal support for devising ways to encourage teacher use of technology aligned with instructional goals–whether delivered through preservice education or inservice professional development or both. Given the continual changes and advances in technology, the need for training is ongoing and must not only be about how to use technology, but also about how to support student learning.

All students will be technologically literate and responsible cybercitizens

Today's world is marked by increasingly rapid social, political, and technological change–change that is becoming increasingly more difficult to predict. As a consequence, in addition to being academically, socially, and emotionally prepared, students will need to be technologically savvy—understanding how to locate information, determine its relevance, determine its accuracy, and integrate it with other sources. In addition, we must help students to remain vigilant in safeguarding personal information and from accessing inappropriate materials.

Research, development and evaluation will shape the next generation of technology applications for teaching and learning

As the use of technology in education becomes more commonplace, it becomes critical to understand what we are learning about what works and what does not. Too often individual schools and districts are left without good information that could guide them in making appropriate investments in technology – investments that could result in tremendous changes to the educational experience for both teachers and students.

Education will drive the E-learning economy

The Internet is fast becoming an engine of innovation in education. As it is revolutionizing business through e-commerce, the Internet is on a course to redefine education. E-learning, or the delivery of education and related services over the Internet, is being touted as the next most innovative application of the Internet, and private investment in education organizations is rapidly expanding. Fostering innovation in education – from the provision of digital learning, digital content, assessment services, tutoring, distance learning, data warehousing, and other forms of instructional technology – is important. Other areas ripe for innovation included ways of: establishing collaboration among schools, libraries, museums, higher education, and industry; evaluating the quality of educational materials and content; and, archiving public domain historical, cultural, and scientific resources.

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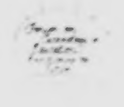
- '96 ET Plan

Graphical Notes taken during the Forum

Graphics created by David Sibbet and Kayla Kirsch of The Grove Consultants International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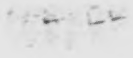
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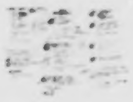
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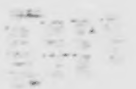
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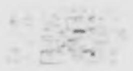
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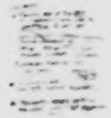
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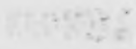
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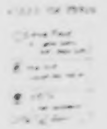
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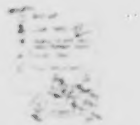
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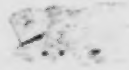
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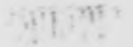
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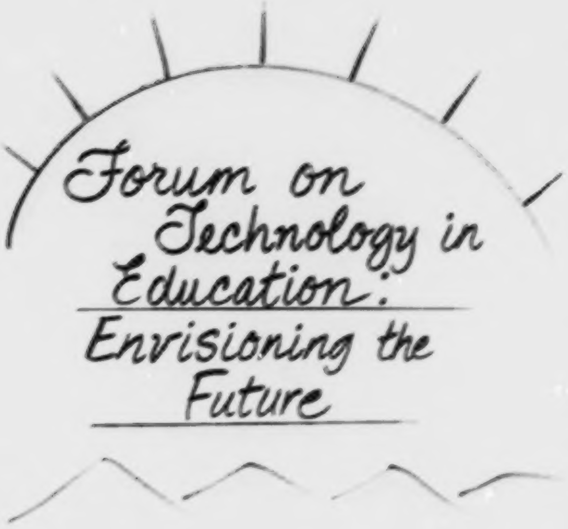
Forum on
Technology in
Education:
Envisioning the
Future

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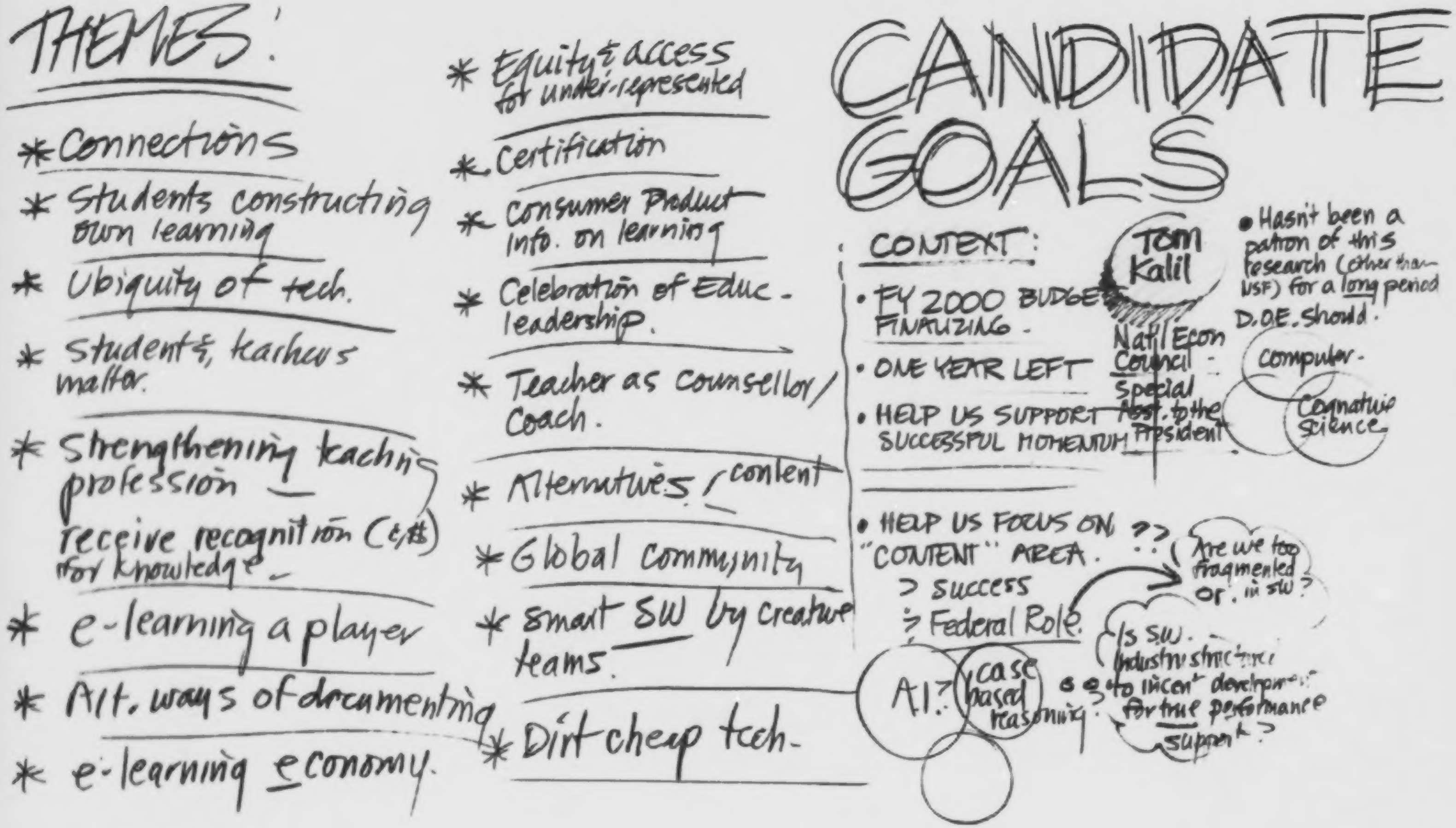

THEMES:

- ✱ Connections
- ✱ Students constructing own learning
- ✱ Ubiquity of tech.
- ✱ Students & teachers matter.
- ✱ Strengthening teaching profession – receive recognition (¢/$) for knowledge –
- ✱ e-learning a player
- ✱ Alt. ways of documenting
- ✱ e-learning economy.
- ✱ Equity & access for under-represented
- ✱ Certification
- ✱ Consumer Product info. on learning
- ✱ Celebration of Educ. leadership.
- ✱ Teacher as counsellor / Coach.
- ✱ Alternatives / content
- ✱ Global community
- ✱ Smart SW by creative teams.
- ✱ Dirt cheap tech.

CANDIDATE GOALS

CONTEXT:

- FY 2000 BUDGET FINALIZING.
- ONE YEAR LEFT
- HELP US SUPPORT SUCCESSFUL MOMENTUM
- HELP US FOCUS ON "CONTENT" AREA. ??
  - > SUCCESS
  - > Federal Role.

Tom Kalil

Nat'l Econ Council – Special Asst. to the President

- Hasn't been a patron of this research (other than NSF) for a long period

D.O.E. should.

computer.

Cognative science.

Are we too fragmented or. in SW?

A.I.? case based reasoning?

Is SW. Industry structured to incent development for true performance support?

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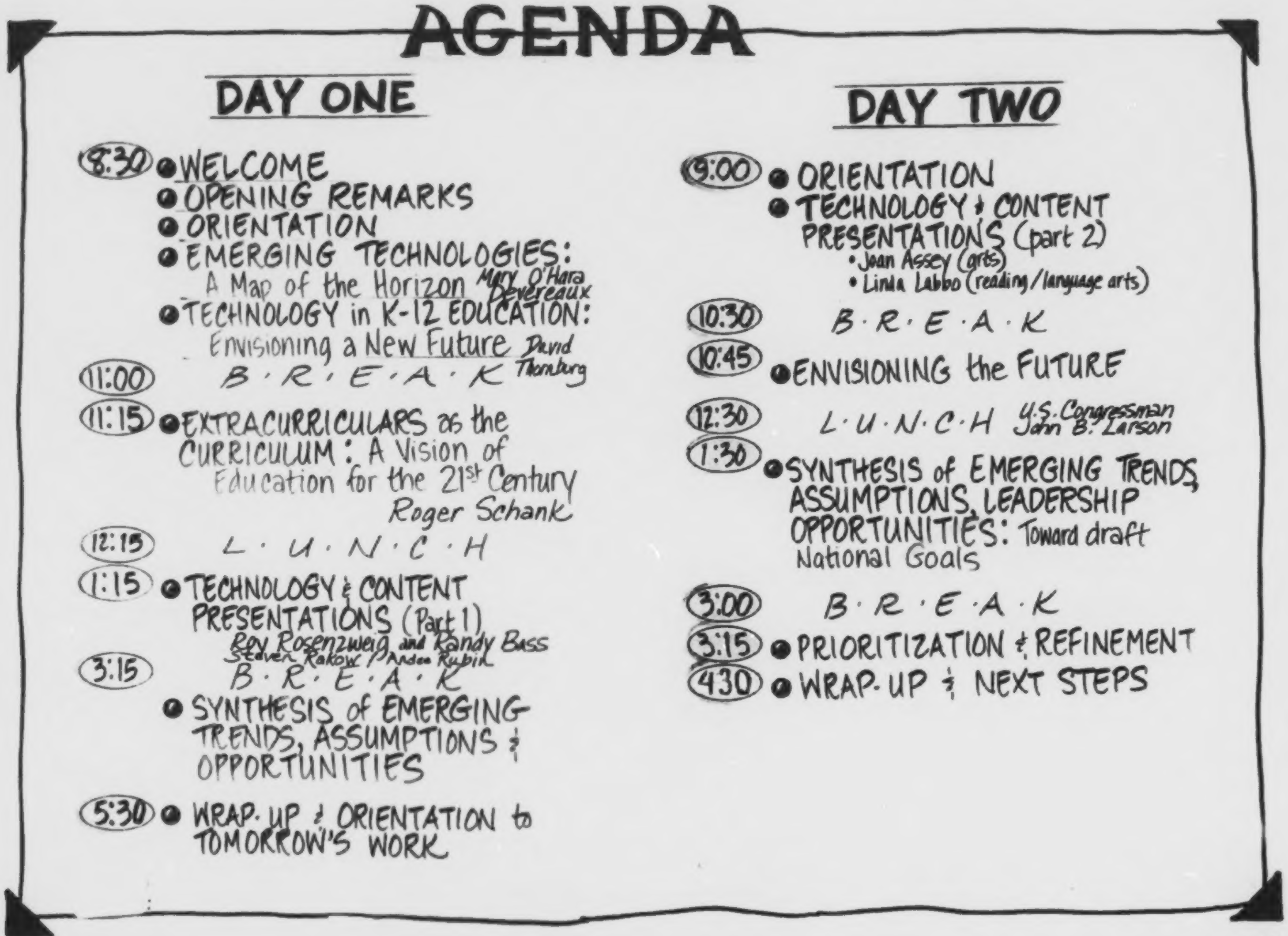

AGENDA

DAY ONE

8:30 • WELCOME
• OPENING REMARKS
• ORIENTATION
• EMERGING TECHNOLOGIES: A Map of the Horizon *Mary O'Hara Devereaux*
• TECHNOLOGY in K-12 EDUCATION: Envisioning a New Future *David Thornburg*
11:00 B·R·E·A·K
11:15 • EXTRACURRICULARS as the CURRICULUM: A Vision of Education for the 21st Century *Roger Schank*
12:15 L·U·N·C·H
1:15 • TECHNOLOGY & CONTENT PRESENTATIONS (Part 1) *Roy Rosenzweig and Randy Bass*, *Steven Rakow / Andee Rubin*
3:15 B·R·E·A·K
• SYNTHESIS of EMERGING TRENDS, ASSUMPTIONS & OPPORTUNITIES
5:30 • WRAP-UP & ORIENTATION to TOMORROW'S WORK

DAY TWO

9:00 • ORIENTATION
• TECHNOLOGY & CONTENT PRESENTATIONS (part 2)
  - Joan Assey (arts)
  - Linda Labbo (reading/language arts)
10:30 B·R·E·A·K
10:45 • ENVISIONING the FUTURE
12:30 L·U·N·C·H *U.S. Congressman John B. Larson*
1:30 • SYNTHESIS of EMERGING TRENDS, ASSUMPTIONS, LEADERSHIP OPPORTUNITIES: Toward draft National Goals
3:00 B·R·E·A·K
3:15 • PRIORITIZATION & REFINEMENT
4:30 • WRAP-UP & NEXT STEPS

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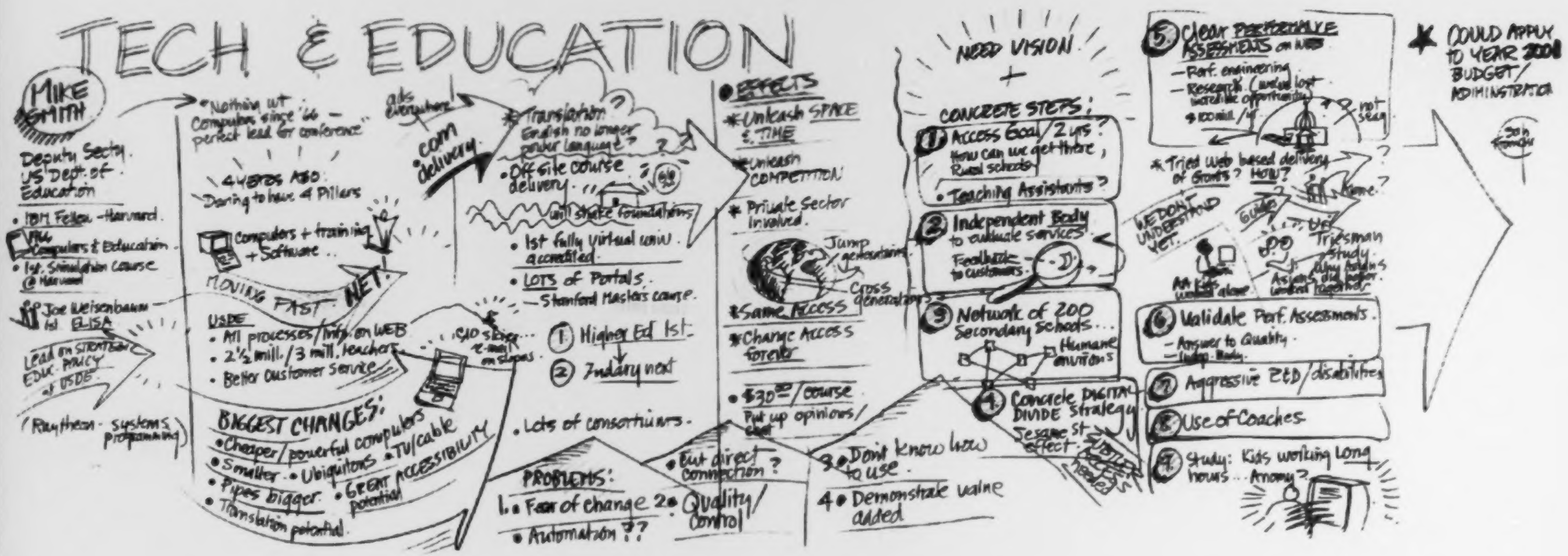
TECH & EDUCATION
MIKE SMITH
Deputy Secty. US Dept. of Education
• IBM Fellow - Harvard.
1st Computers & Education
• 1st. Simulation Course @ Harvard
Joe Weisenbaum 1st ELISA
Lead on STRATEGIC EDUC. POLICY at USDE.
(Raytheon - systems programming)
• "Nothin wt Computers since '66 - perfect lead for conference"
44 yrs AGO
Daring to have 4 Pillars
Computers + training + Software ..
MOVING FAST NET.
USDE
• All processes/info. on WEB
• 2½ mill./3 mill. teachers
• Better Customer Service
BIGGEST CHANGES:
• Cheaper/powerful computers
• Smaller • Ubiquitous • TV/cable
• Pipes bigger. • GREAT ACCESSIBILITY potential
• Translation potential.
ads everywhere!
.com delivery.
* Translation English no longer gender language?
• Off site course delivery.
will shake foundations
• 1st fully virtual univ. accredited.
• LOTS of Portals.
— Stanford Masters course.
$10 sticker e-mail on slopes.
① Higher Ed 1st.
② Indary next
• Lots of consortiums.
PROBLEMS:
1. • Fear of change
• Automation??
• But direct connection?
2. • Quality/Control
3. • Don't know how to use.
4. • Demonstrate value added
• EFFECTS
* Unleash SPACE & TIME
* Unleash COMPETITION
* Private Sector Involved.
Jump generations
Cross generations
* Same Access
* Change Access forever
• $30⁰⁰/course
Put up opinions/chat
NEED VISION + CONCRETE STEPS;
① Access Goal/2 yrs? How can we get there, Rural schools
• Teaching Assistants?
② Independent Body to evaluate services!
Feedback to customers.
③ Network of 200 Secondary Schools...
Humane environs
④ Concrete DIGITAL DIVIDE Strategy
Sesame St effect.
Subtle forces needed
⑤ Clear PERFORMANCE ASSESSMENTS on WEB
— Perf. engineering
— Research. (value lost satellite opportunity)
$100 mill./yr
not sexy
* Tried Web based delivery of Grants? HOW?
Guide
Home?
WE DON'T UNDERSTAND YET.
AA kids worked alone
U.T. Triesman study. Why Asians did better. Asians worked together
⑥ Validate Perf. Assessments.
— Answer to Quality.
— Indep. Body.
⑦ Aggressive Z.E.D/disabilities
⑧ Use of Coaches
⑨ Study: Kids working Long hours... Anomy?
★ COULD APPLY TO YEAR 2001 BUDGET/ADMINISTRATION

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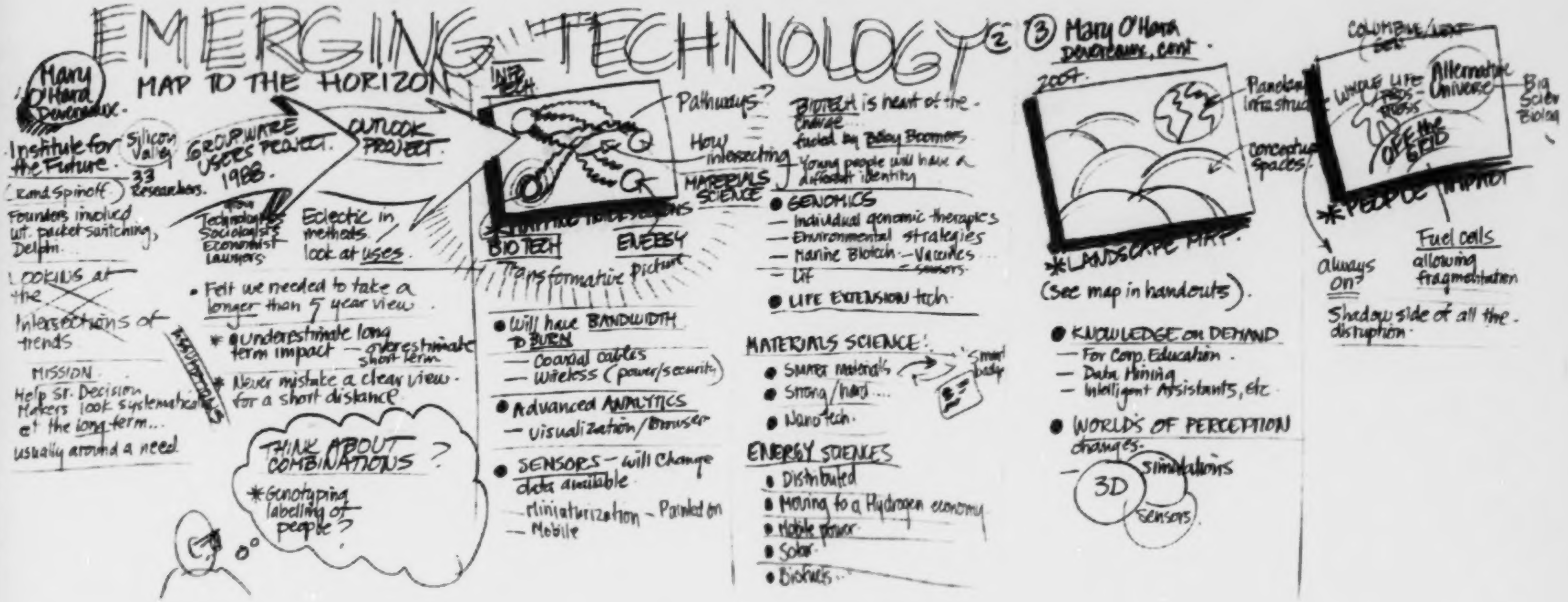
EMERGING TECHNOLOGY ②
MAP TO THE HORIZON
Mary O'Hara Devereaux.
Institute for the Future.
Silicon Valley
33 Researchers.
Rand Spinoff
Founders involved w/. packet switching, Delphi.
~~Looking at the~~ Intersections of trends
MISSION
Help Sr. Decision Makers look systematically at the long term...
usually around a need
GROUPWARE USERS PROJECT. 1988.
OUTLOOK PROJECT.
Technologists Sociologists Economist Lawyers
Eclectic in methods / look at uses.
ASSUMPTIONS
• Felt we needed to take a longer than 5 year view.
* • Underestimate long term impact — overestimate short term
* Never mistake a clear view for a short distance
THINK ABOUT COMBINATIONS?
* Genotyping labelling of people?
INFO TECH
Pathways?
How intersecting
MATERIALS SCIENCE
BIOTECH
ENERGY
Transformative picture
• Will have BANDWIDTH TO BURN
— Coaxial cables
— Wireless (power/security)
• Advanced ANALYTICS
— visualization/browser
• SENSORS — will change data available
— Miniaturization — Painted on
— Mobile
BIOTECH is heart of the change...
fueled by Baby Boomers
Young people will have a different identity
• GENOMICS
— Individual genomic therapies
— Environmental strategies
— Marine Biotech — Vaccines ...
— Sensors
— UF
• LIFE EXTENSION tech
MATERIALS SCIENCE:
• Smart materials
• Strong/hard...
• Nano tech.
Smart body
ENERGY SCIENCES
• Distributed
• Moving to a Hydrogen economy
• Mobile power
• Solar
• Biofuels...
③ Mary O'Hara Devereaux, cont.
2004.
Planetary Infrastructure
Conceptual Spaces.
* LANDSCAPE MAP.
(See map in handouts).
• KNOWLEDGE on DEMAND
— For Corp. Education.
— Data Mining
— Intelligent Assistants, etc.
• WORLD'S OF PERCEPTION changes.
— 3D
simulations
sensors.
COLUMBINE/NEXT GEN
WHOLE LIFE PROCESS
Alternative Universe
OFF the GRID
Big Science Biology
* PEOPLE IMPACT
Always on?
Fuel cells allowing fragmentation
Shadow side of all the disruption.

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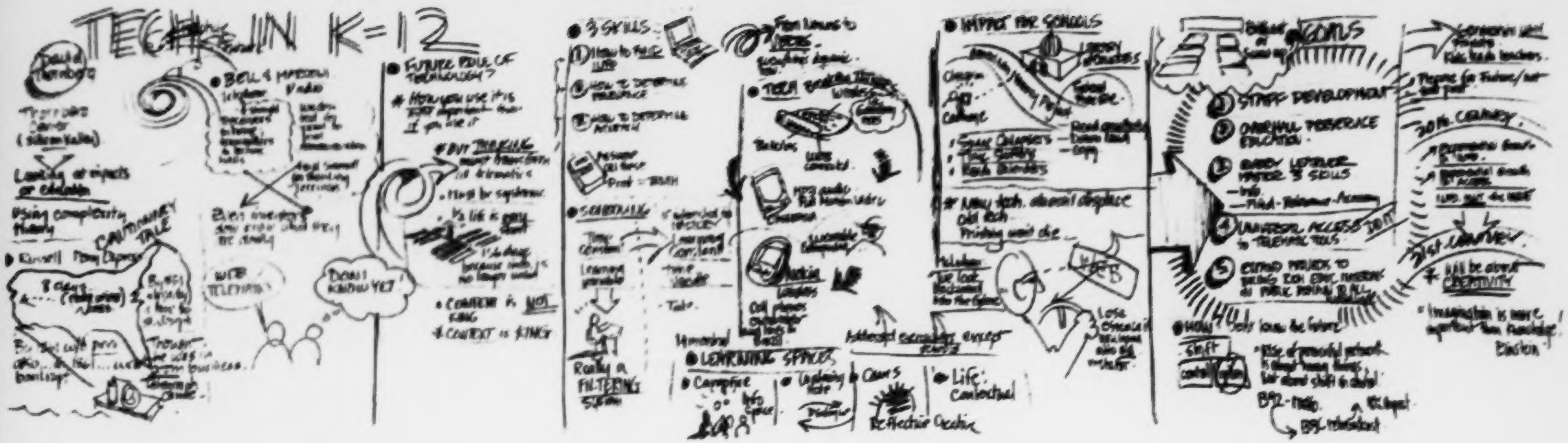
Graphic Page 6


TECH IN K=12
David Thornburg
Silicon Valley
Looking at impacts on education
Using complexity theory
CAUTIONARY TALE
Russell
BELL & HOWELL
Web
TELEVISION
DON'T KNOW YET
FUTURE ROLE OF TECHNOLOGY?
How you use it is more important than if you use it
BUT THINKING
Must be synchronous
CONTENT is NOT KING
CONTEXT is KING
3 SKILLS
1 How to find info
2 HOW TO DETERMINE RELEVANCE
3 HOW TO DETERMINE ACCURACY
Print = TRUTH
SCAFFOLDING
Time Content
Learning content
Really a FILTERING System
From Laws to ...
TECH
Wireless
Cell phones
LEARNING SPACES
Campfire
Info Space
Dialogue
Caves
Reflective Creative
Life: Contextual
IMPACT FOR SCHOOLS
Space Changers
New tech. doesn't displace old tech.
Printing won't die
Lose Chance
GOALS
1 STAFF DEVELOPMENT
2 OVERHAUL PRESERVICE EDUCATION
3 EVERY LEARNER MASTER 3 SKILLS
4 UNIVERSAL ACCESS to TELECOMM TOOLS
5 EXTEND PROJECTS TO BRING ... TO ALL
HOW ... shift
Rise of powerful network
20th CENTURY
21st CENTURY
Will be about CREATIVITY
"Imagination is more important than knowledge!"
Einstein

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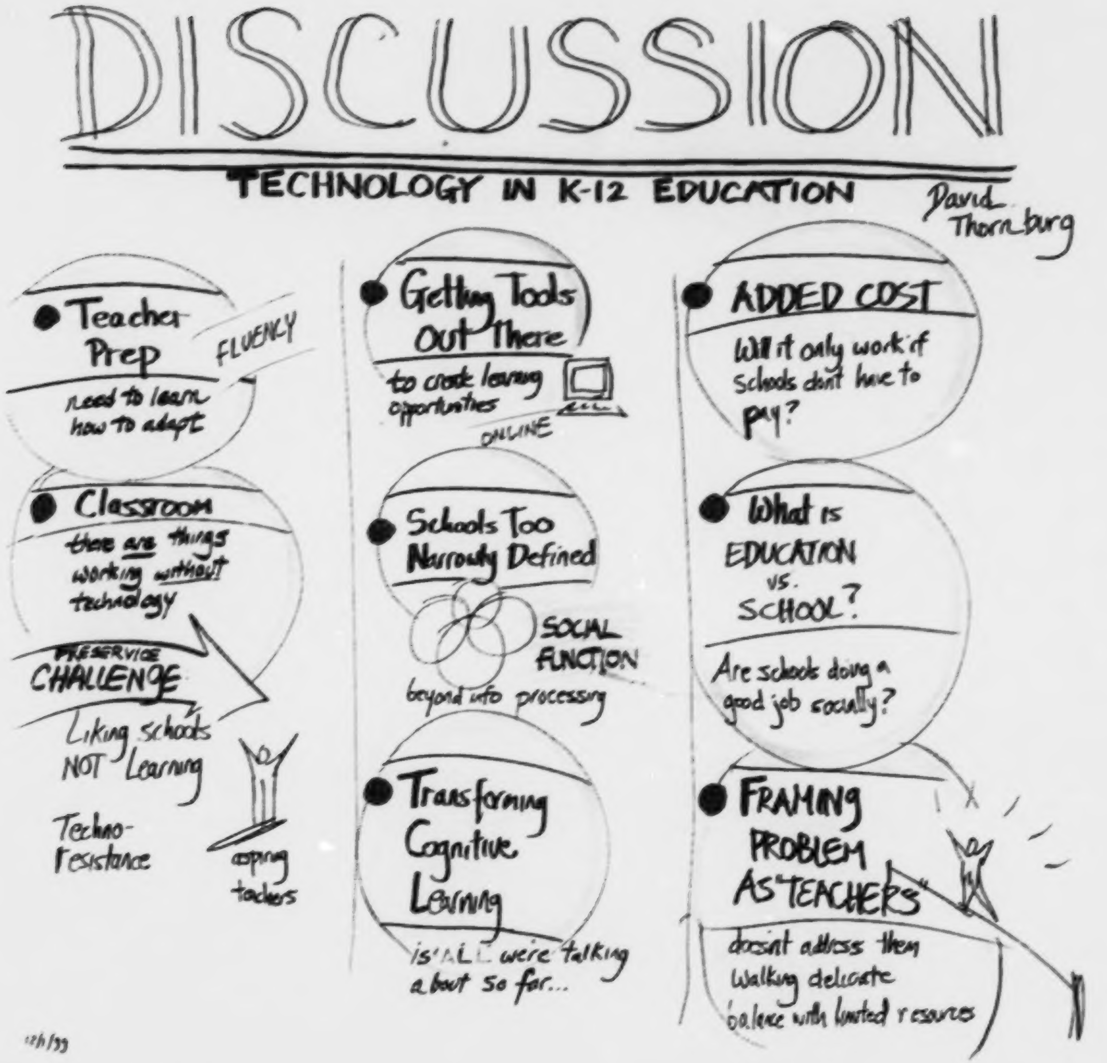
DISCUSSION
TECHNOLOGY IN K-12 EDUCATION
David Thornburg
Teacher Prep
FLUENCY
need to learn how to adapt
Classroom
there are things working without technology
PRESERVICE CHALLENGE
Liking schools NOT Learning
Techno-resistance
coping teachers
Getting Tools Out There
to create learning opportunities
ONLINE
Schools Too Narrowly Defined
SOCIAL FUNCTION
beyond info processing
Transforming Cognitive Learning
is ALL we're talking about so far...
ADDED COST
Will it only work if schools don't have to pay?
What is EDUCATION vs. SCHOOL?
Are schools doing a good job socially?
FRAMING PROBLEM AS "TEACHERS"
doesn't address them
Walking delicate balance with limited resources
12/1/99

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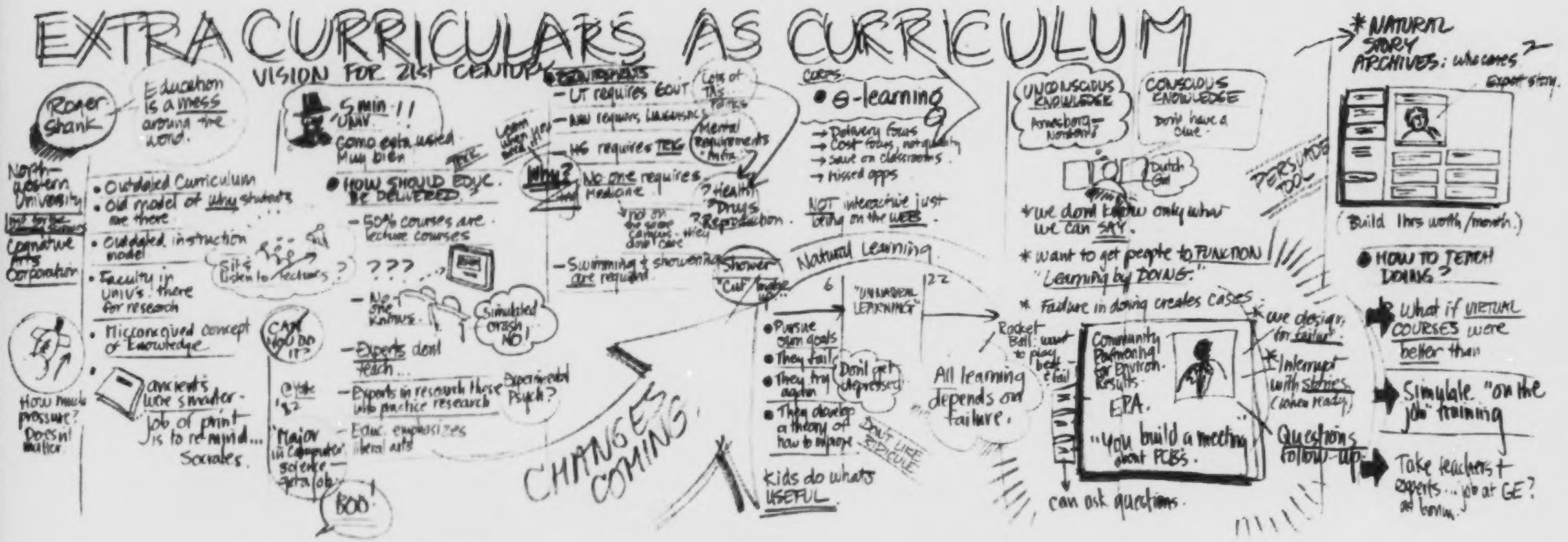
EXTRACURRICULARS AS CURRICULUM
VISION FOR 21st CENTURY
Roger Shank
Education is a mess around the world.
North-western University
Cognitive Arts Corporation
• Outdated Curriculum
• Old model of why students are there
• Outdated instruction model
Sits & listen to lectures ?
• Faculty in Univ's there for research
• Misconceived concept of knowledge
ancients were smarter -
Job of print is to re-mind... Socrates.
How much pressure? Doesn't matter.
5 min !! UNIV.
Como esta usted Muy bien
• HOW SHOULD EDUC. BE DELIVERED?
- 50% courses are lecture courses
???
- No one knows.
Simulated crash NO!
- Experts don't teach...
- Experts in research those who practice research
Experimental Psych?
- Educ. emphasizes liberal arts
CAN YOU DO IT?
@Yale '82
"Major in Computer science - get a job."
BOO!
• REQUIREMENTS
- UT requires GOVT
- NW requires LANGUAGE
- HS requires TRIG
Lots of TAs
Mental requirements
Learn when need it
Why?
No one requires medicine
not on the same campus - they don't care
? Health ? Drugs ? Reproduction.
- Swimming & showering are required
Shower "Cut" make up...
CHANGES COMING
CORPS.
• e-learning
→ Delivery focus
→ Cost focus, not quality
→ save on classrooms.
→ missed opps
NOT interactive just being on the WEB.
Natural Learning
6
"UNNATURAL LEARNING"
22
• Pursue own goals
• They fail
• They try again
• They develop a theory of how to improve
Don't get depressed
DON'T LIKE RIDICULE
Kids do whats USEFUL.
All learning depends on failure.
Rocket Ball: want to play best & fail
UNCONSCIOUS KNOWLEDGE
Annenberg - Northwest?
CONSCIOUS KNOWLEDGE
Don't have a clue.
Dutch Girl
* we don't know only what we can SAY.
* want to get people to FUNCTION "Learning by DOING."
* Failure in doing creates cases
Community Partnering for Environ. Results
EPA.
"You build a meeting about PCB's."
can ask questions.
* we design for failure.
* Interrupt with stories. (when ready)
Questions follow-up.
PERSUADE TOO
* NATURAL STORY ARCHIVES: who cares? Expert story.
(Build this worth/month.)
• HOW TO TEACH DOING?
What if VIRTUAL COURSES were better than
Simulate "on the job" training
Take teachers + experts... job at GE? at home.

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Forum Report
White Papers

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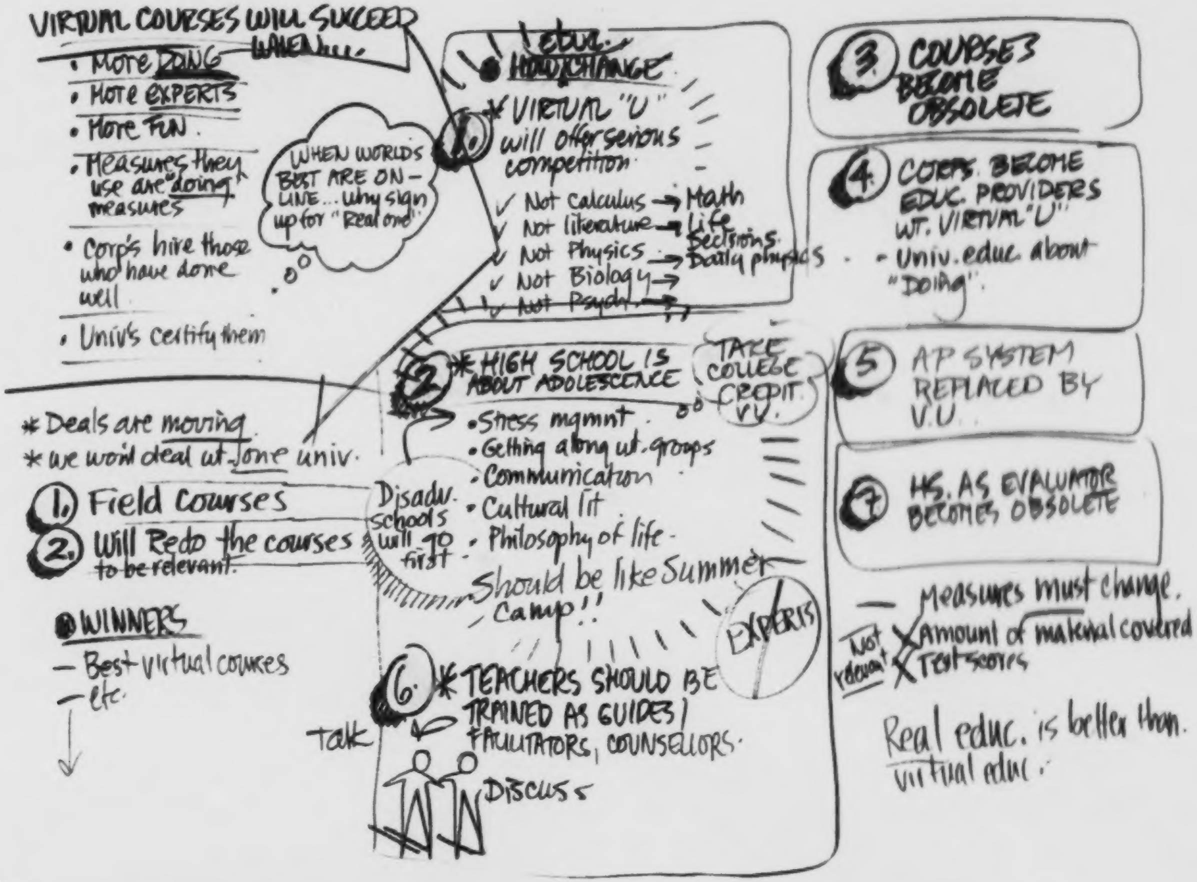

VIRTUAL COURSES WILL SUCCEED WHEN....

- More DOING
- More EXPERTS
- More FUN.
- Measures they use are "doing" measures
- Corp's hire those who have done well
- Univ's certify them

WHEN WORLD'S BEST ARE ON-LINE... Why sign up for "Real one"

* Deals are moving.
* we won't deal wt. one univ.

① Field courses
② Will Redo the courses to be relevant.

WINNERS
— Best virtual courses
— etc.

educ. HAS TO CHANGE

① * VIRTUAL "U" will offer serious competition

✓ Not Calculus → Math
✓ Not literature → Life Sections.
✓ Not Physics → Daily physics
✓ Not Biology →
✓ Not Psych. →

② * HIGH SCHOOL IS ABOUT ADOLESCENCE

TAKE COLLEGE CREDIT V.U.

- Stress mgmnt.
- Getting along wt. groups
- Communication
- Cultural lit
- Philosophy of life

Disadv. schools will go first

Should be like Summer Camp!!

EXPERTS

⑥ * TEACHERS SHOULD BE TRAINED AS GUIDES / FACILITATORS, COUNSELLORS.

Talk

Discuss

③ COURSES BECOME OBSOLETE

④ CORPS. BECOME EDUC. PROVIDERS WT. VIRTUAL "U"
- Univ. educ. about "Doing".

⑤ AP SYSTEM REPLACED BY V.U.

⑦ HS. AS EVALUATOR BECOMES OBSOLETE

— Measures must change.

Not relevant
✗ Amount of material covered
✗ Test scores

Real educ. is better than virtual educ.

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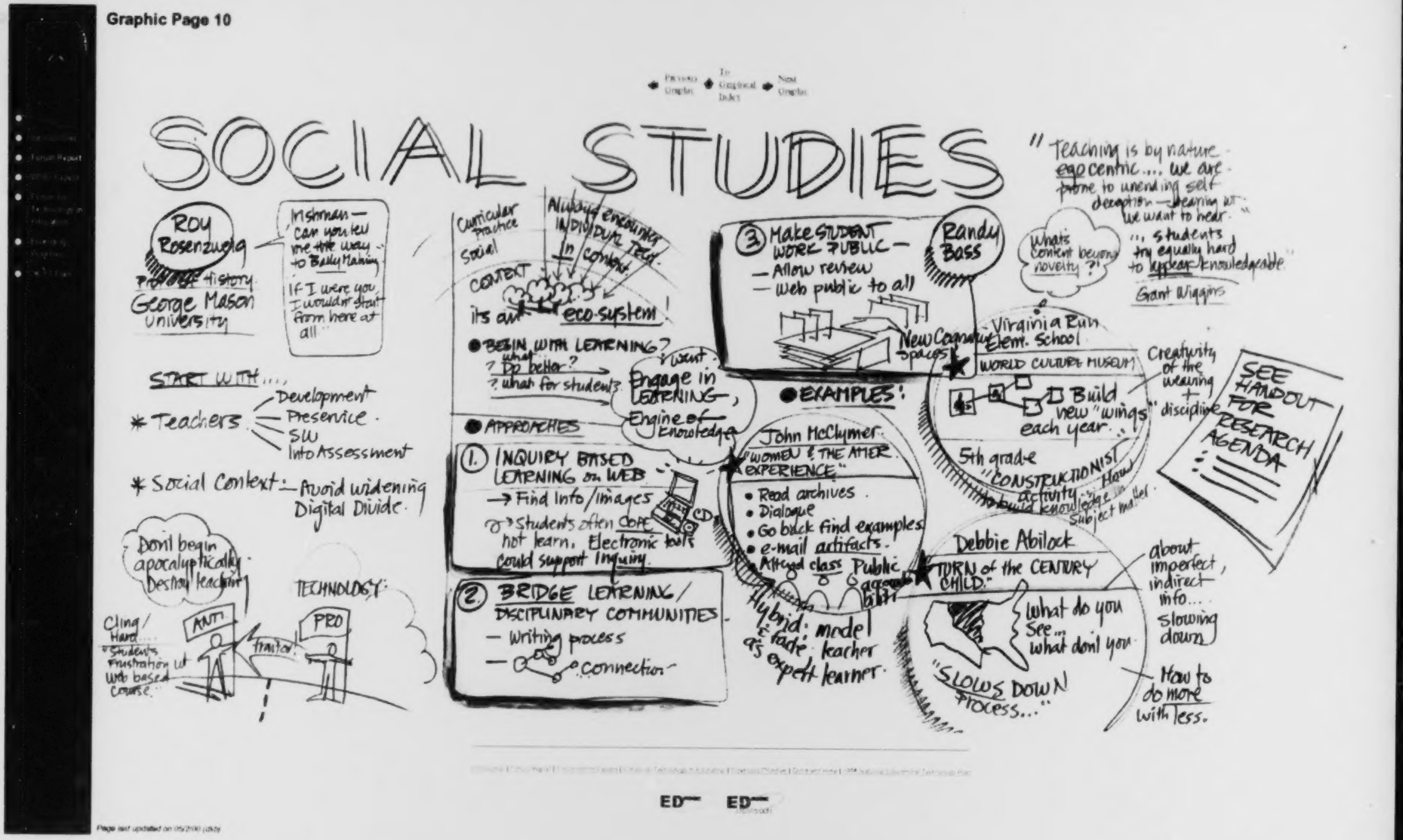

Graphic Page 10

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SOCIAL STUDIES
"Teaching is by nature egocentric.... we are prone to unending self deception — hearing what we want to hear."
".., students try equally hard to appear knowledgeable"
Grant Wiggins
What's content beyond novelty?
ROY Rosenzweig
Professor History
George Mason University
Irishman — can you tell me the way to Ballymahon
If I were you, I wouldn't start from here at all
START WITH...
* Teachers
Development
Preservice
SW
Into Assessment
* Social Context: Avoid widening Digital Divide.
Don't begin apocalyptically. Destroy teaching
TECHNOLOGY:
Cling / Hard....
* Students frustration w/ Web based course.
ANTI
traitor!
PRO
Curricular Practice
Social
CONTEXT
Always encounter INDIVIDUAL TECH. In context
it's an eco-system!
● BEGIN WITH LEARNING?
? what do better?
? what for students
Want.... Engage in LEARNING,
Engine of knowledge
● APPROACHES
1. INQUIRY BASED LEARNING on WEB
→ Find Info / images
Students often cope not learn. Electronic tools could support inquiry.
CD
2. BRIDGE LEARNING / DISCIPLINARY COMMUNITIES.
— Writing process
— connection
3. MAKE STUDENT WORK PUBLIC —
— Allow review
— Web public to all
New Cognitive Spaces
Randy Bass
● EXAMPLES:
John McClymer
"WOMEN & THE AMER. EXPERIENCE."
• Read archives
• Dialogue
• Go back find examples
• e-mail artifacts.
• Attend class Public
Public agenda
Hybrid: model & facilitate teacher as expert learner.
Virginia Run Elem. School
WORLD CULTURE MUSEUM
Build new "wings" each year.
5th grade
"CONSTRUCTIONIST activity... How to build knowledge in subject matter
Creativity of the learning + discipline
SEE HANDOUT FOR RESEARCH AGENDA
Debbie Abilock
"TURN of the CENTURY CHILD."
What do you See... what don't you
"SLOWS DOWN Process..."
about imperfect, indirect info... slowing down
How to do more with less.
ED
ED

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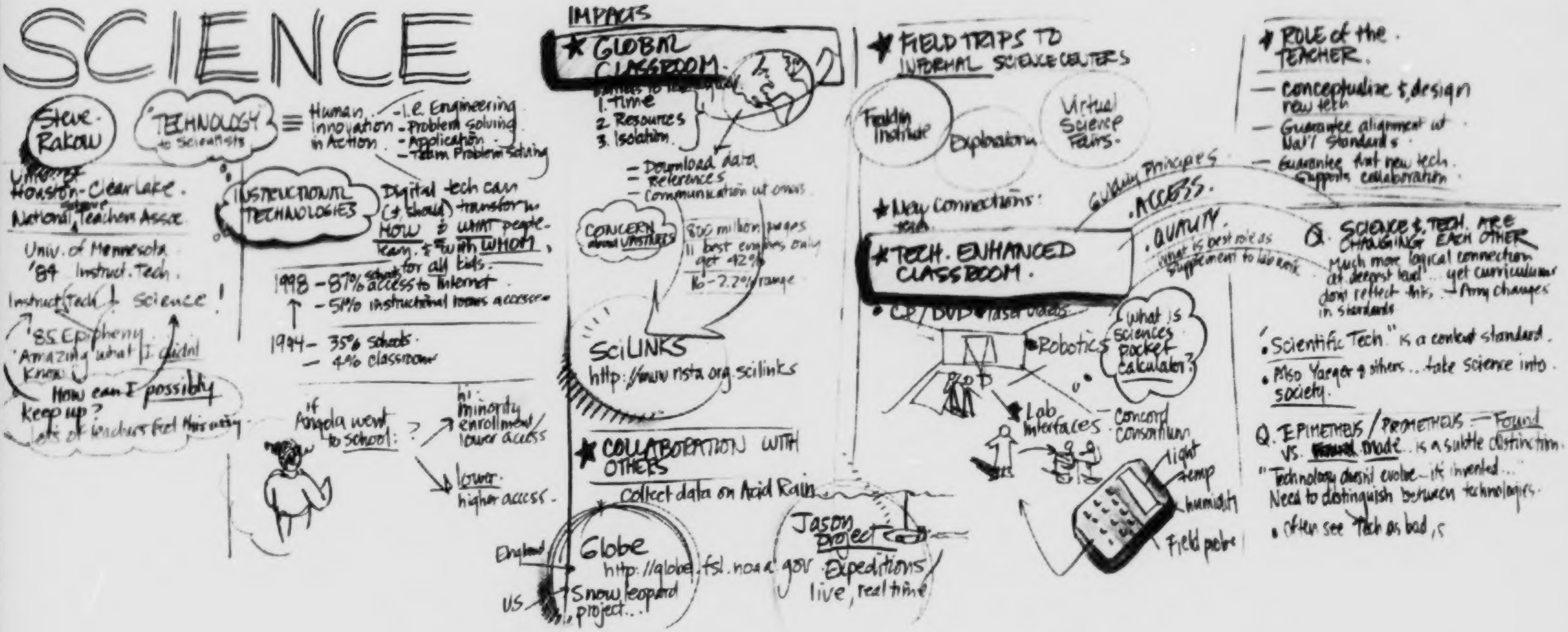

SCIENCE

Steve Rakow

"TECHNOLOGY" to Scientists ≡ Human Innovation in Action.
- i.e. Engineering.
- Problem solving.
- Application.
- Team Problem Solving

University of Houston-Clearlake.

National Science Teachers Assoc.

Univ. of Mennesota '84 Instruct. Tech.

Instruct. Tech + Science!

'85 Epiphany. 'Amazing what I didn't know.'

How can I possibly keep up?

Lots of teachers feel this way.

INSTRUCTIONAL TECHNOLOGIES

Digital tech can (& should) transform HOW & WHAT people learn & with WHOM, for all kids.

1998 – 87% schools access to Internet.
– 51% instructional rooms access.

1994 – 35% schools.
– 4% classrooms

if Angela went to school: ?
→ hi minority enrollment/lower access
→ lower. higher access.

IMPACTS

★ GLOBAL CLASSROOM.

Barriers to learning:
1. Time
2. Resources
3. Isolation.

= Download data
= References
– Communication w/ others.

CONCERN about VASTNESS

800 million pages
11 best engines only get 42%
16 – 2.2% range

SciLINKS http://www.nsta.org.scilinks

★ COLLABORATION WITH OTHERS

Collect data on Acid Rain.

Globe http://globe.fsl.noaa.gov
England
US
Snow leopard project...

Jason Project. Expeditions live, real time

★ FIELD TRIPS TO INFORMAL SCIENCE CENTERS

Franklin Institute

Exploratorium

Virtual Science Fairs.

★ New connections: tech

★ TECH. ENHANCED CLASSROOM.

Guiding Principles
- ACCESS.
- QUALITY. what is best role as supplement to lab work.

• CD/DVD • laser videos

• Robotics

What is sciences pocket calculator?

★ Lab Interfaces. Concord Consortium

light
temp
humidity
Field probe

★ ROLE of the TEACHER.
- conceptualize & design new tech
- Guarantee alignment w/ Nat'l Standards.
- Guarantee that new tech. supports collaboration.

Q. SCIENCE & TECH. ARE CHANGING EACH OTHER

Much more logical connection at deepest level... yet curriculums don't reflect this. – Any changes in standards

• "Scientific Tech." is a content standard.

• Also Yaeger & others... take science into society.

Q. EPIMETHEUS / PROMETHEUS – Found vs. ~~Found~~ made... is a subtle distinction.

"Technology doesn't evolve – it's invented..."
Need to distinguish between technologies.

• often see Tech as bad, 's

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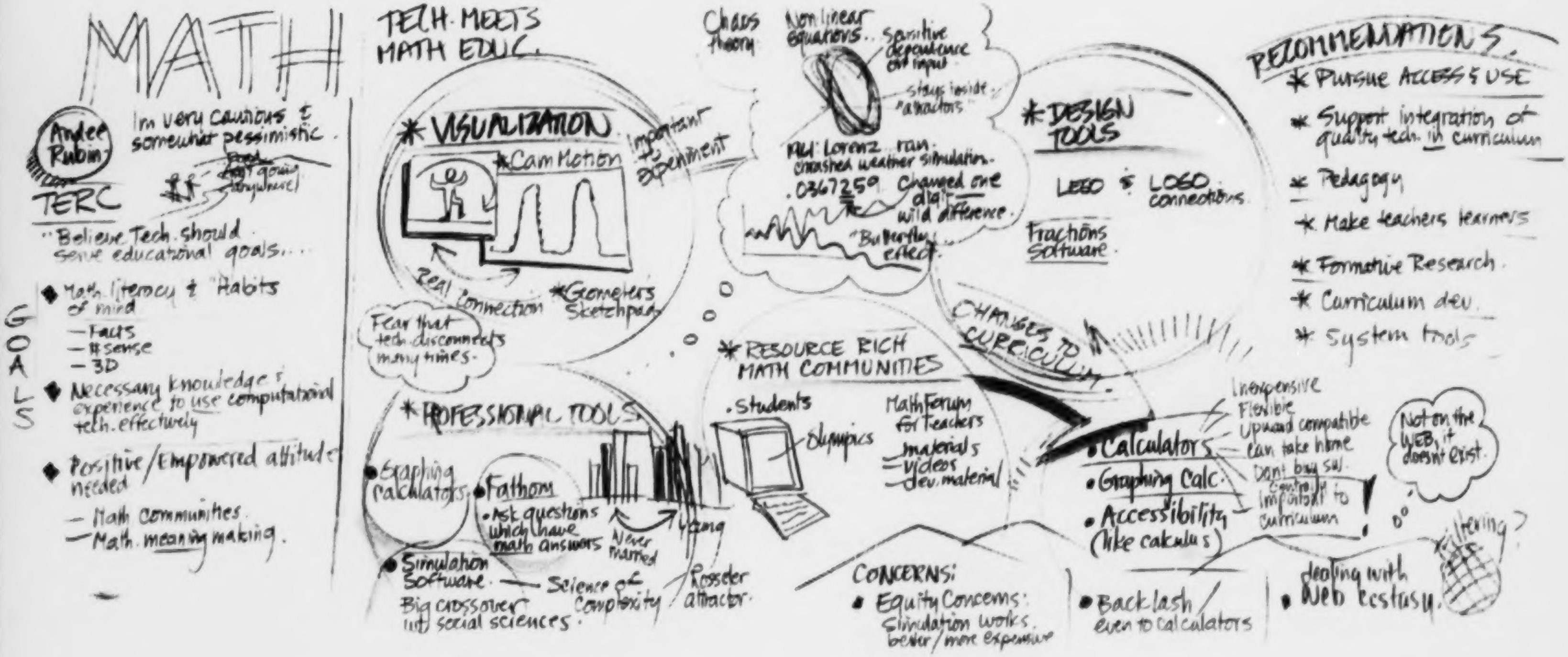
MATH
Andee Rubin
TERC
Im very cautious & somewhat pessimistic.
not going anywhere!
"Believe Tech. should serve educational goals...
GOALS
◆ Math literacy & "Habits of mind"
— Facts
— # sense
— 3D
◆ Necessary knowledge & experience to use computational tech. effectively
◆ Positive/Empowered attitude needed
— Math communities.
— Math. meaning making.
TECH. MEETS MATH EDUC.
* VISUALIZATION
* Cam Motion
Real Connection
* Geometers Sketchpad
Important to experiment
Fear that tech. disconnects many times.
Chaos theory
Non linear equations... Sensitive dependence on input.
stays inside "attractors"
Ed: Lorenz ran crashed weather simulation.
.0367259 Changed one digit - wild difference.
"Butterfly effect".
* DESIGN TOOLS
LEGO & LOGO connections.
Fractions Software.
* PROFESSIONAL TOOLS
• Graphing calculators.
• Fathom
• Ask questions which have math answers
Never married
Young
• Simulation Software. — Science of Complexity
Big crossover w/ social sciences.
Rossler attractor.
* RESOURCE RICH MATH COMMUNITIES
. Students
Olympics
MathForum for teachers
— materials
— videos
— dev. material
CHANGES TO CURRICULUM
• Calculators
• Graphing Calc.
• Accessibility (like calculus)
Inexpensive
Flexible
Upward compatible
can take home
Don't buy sw.
Centrally important to curriculum!
Not on the WEB, it doesn't exist.
Filtering?
CONCERNS:
• Equity Concerns: Simulation works better/more expensive
• Backlash/ even to calculators
• dealing with Web ecstasy.
RECOMMENDATIONS.
* Pursue ACCESS & USE
* Support integration of quality tech. in curriculum
* Pedagogy
* Make teachers learners
* Formative Research.
* Curriculum dev.
* System tools

ED ED

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Graphic Page 13a

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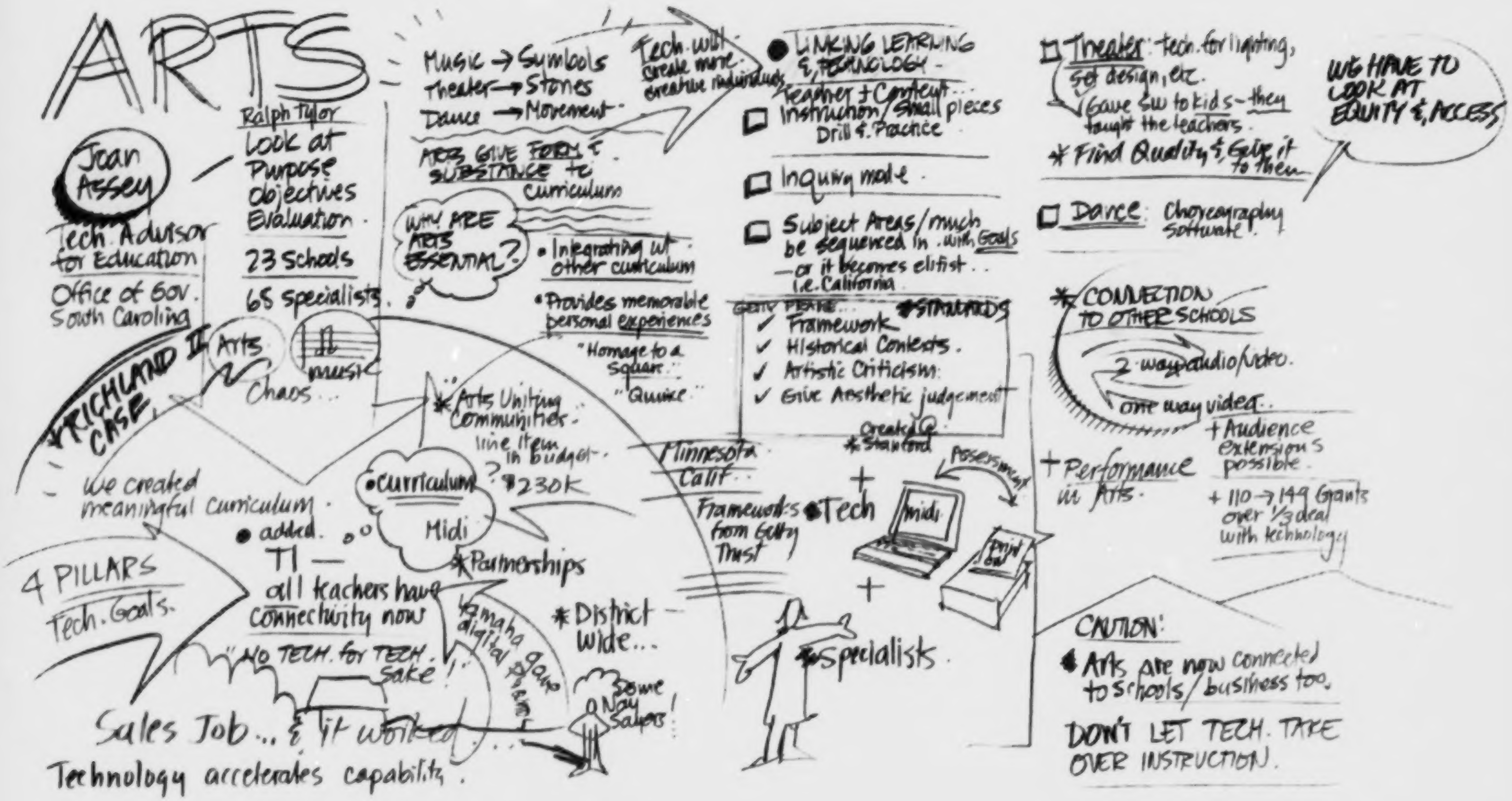
ARTS
Joan Assey
Tech. Advisor for Education
Office of Gov. South Carolina
Ralph Tylor
Look at Purpose objectives Evaluation.
23 Schools
65 specialists.
Music → Symbols
Theater → Stories
Dance → Movement.
Tech. will create more creative individuals
ARTS GIVE FORM & SUBSTANCE to curriculum
WHY ARE ARTS ESSENTIAL?
• Integrating w/ other curriculum
• Provides memorable personal experiences
"Homage to a Square."
"Quince"
● LINKING LEARNING & TECHNOLOGY -
Teacher + Content...
☐ Instruction/Small pieces Drill & Practice.
☐ Inquiry mode.
☐ Subject Areas/much be sequenced in. with Goals — or it becomes elitist.. i.e. California
GETTY PLANE... *STANDARDS
✓ Framework
✓ Historical Contexts.
✓ Artistic Criticism:
✓ Give Aesthetic judgement
Created @ *Stanford
☐ Theater: tech. for lighting, set design, etc.
Gave sw to kids - they taught the teachers.
* Find Quality & Give it to them
WE HAVE TO LOOK AT EQUITY & ACCESS
☐ Dance: Choreography Software.
* CONNECTION TO OTHER SCHOOLS
2 way audio/video.
one way video..
+ Audience extensions possible.
+ Performance in Arts.
+ 110 → 149 Grants over 1/3 deal with technology
*RICHLAND II CASE
Arts
Chaos...
music
* Arts Uniting Communities.
line item in budget..
? $230K
Minnesota.
Calif..
Frameworks from Getty Trust
• Tech
midi
Possessment
print out
+
+
* Specialists.
We created meaningful curriculum.
• added.
T1 —
all teachers have connectivity now
• Curriculum
Midi
* Partnerships
Yamaha gave digital pianos
* District wide...
4 PILLARS
Tech. Goals.
"NO TECH. for TECH. Sake!"
Some Nay Sayers!
Sales Job... & it worked...
Technology accelerates capability.
CAUTION:
• Arts are now connected to schools/business too.
DON'T LET TECH. TAKE OVER INSTRUCTION.

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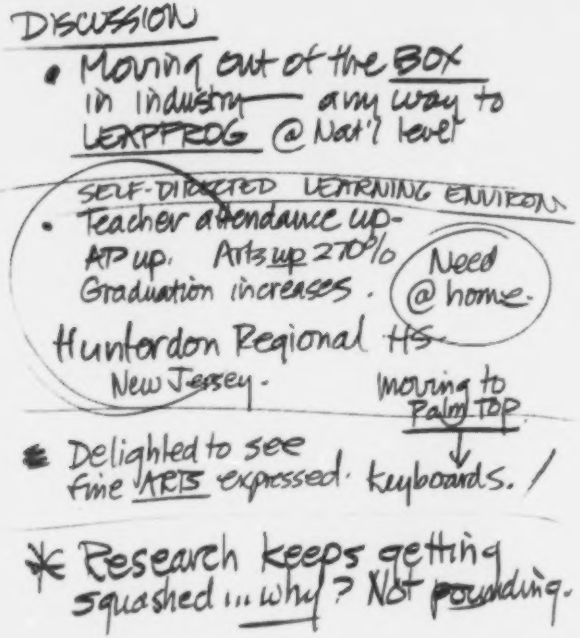

DISCUSSION

- Moving out of the BOX in industry — any way to LEAPFROG @ Nat'l level

SELF-DIRECTED LEARNING ENVIRON.

- Teacher attendance up. AP up. Arts up 270% Graduation increases.

Need @ home.

Hunterdon Regional HS. New Jersey.

moving to Palm TOP.

- Delighted to see fine ARTS expressed.

keyboards.

* Research keeps getting squashed ... why? Not pounding.

Introduction | Forum Report | Forum White Papers | Forum on Technology in Education | Emerging Priorities | Comment Here | 1996 National Educational Technology Plan

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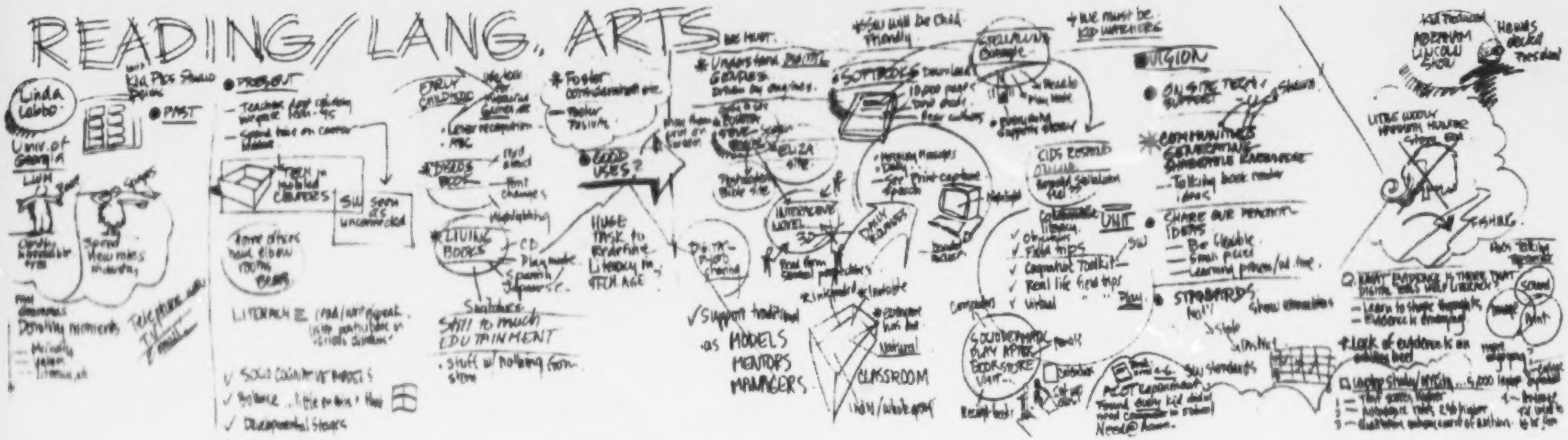
READING/LANG. ARTS
Linda Labbo
Univ. of Georgia
PAST
PRESENT
Teacher
SW seen as uncontrolled
LITERACY = read/write/speak.
✓ SOLID COGNITIVE MODELS
✓ Developmental Stages
Telephone
TV
E-mail
EARLY CHILDHOOD
Letter recognition
ABC
LIVING BOOKS
CD
Playmode
Spanish/Japanese
Highlighting
Font changes
Still to much EDUTAINMENT
Stuff w/ nothing from store
Foster
GOOD USES?
HUGE TASK to Redefine Literacy in TECH AGE
we must.
Understand
Digital Photo Sharing
ELIZA site
INTERACTIVE NOVEL 3D
✓ Support traditional
as MODELS MENTORS MANAGERS.
CLASSROOM
indiv/whole group
SW will be Child friendly
SOFTBOOKS Download
10,000 pages
Spellaway Example
DAILY RECORDS
CIDS RESEARCH ONLINE
✓ Field trips
✓ Real life field trips
✓ Virtual
Computers
SOUNDMARK PLAY AFTER BOOKSTORE Visit...
Need@ home.
we must be KID WATCHERS
VISION
ON SITE TECH / SUPPORT
COMMUNITIES
Talking book reader ideas
UNIT
SHARE OUR ideas
Be flexible
Small pieces
STANDARDS
SW standards
ABRAHAM LINCOLN SHOW
Heads
President
LITTLE WOODY
Lack of evidence is an
Sound
Point

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Forum Report

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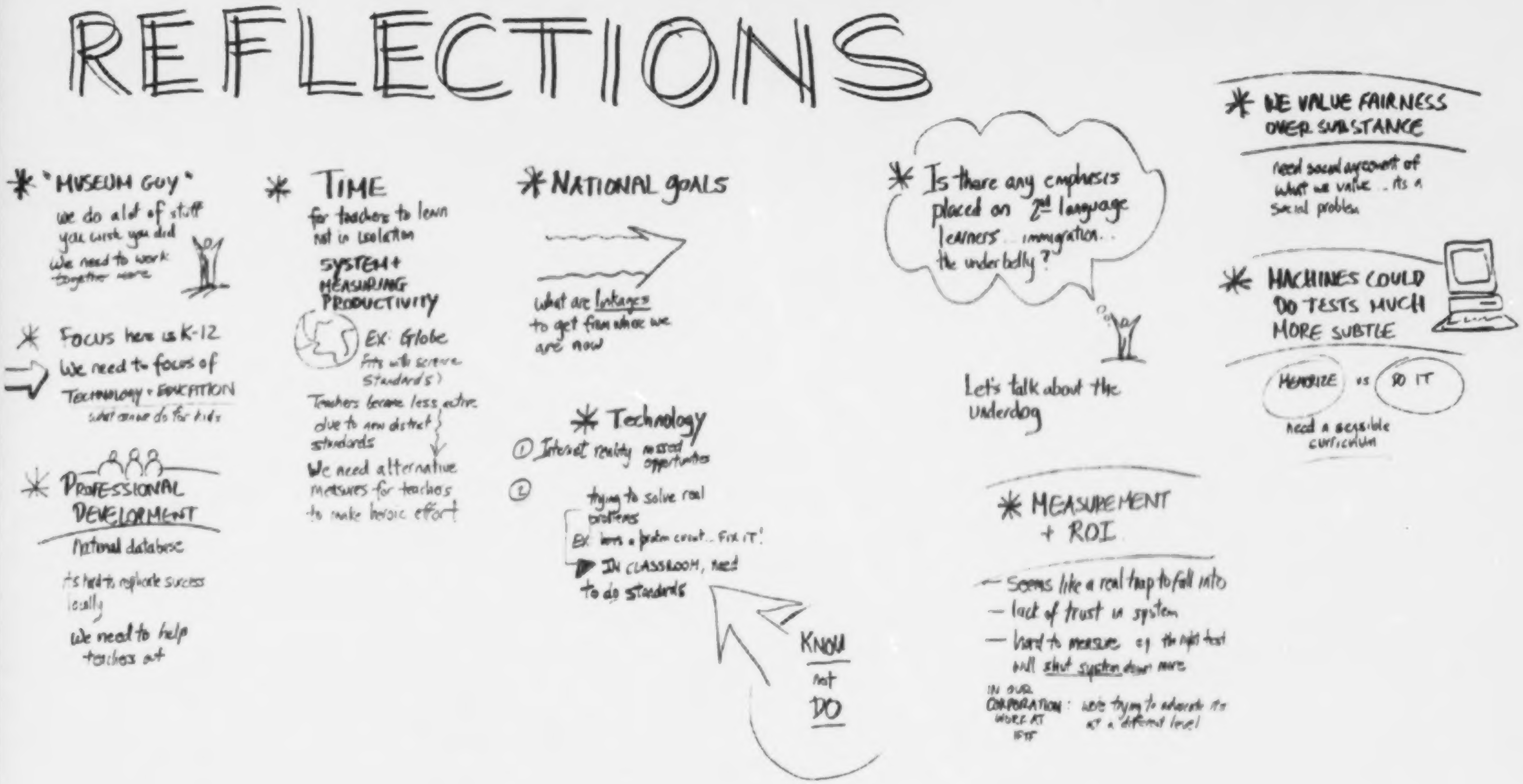

REFLECTIONS

✱ "MUSEUM GUY"
we do a lot of stuff
you wish you did
We need to work
together more

✱ Focus here is K-12
⇨ We need to focus of
TECHNOLOGY + EDUCATION
what can we do for kids

✱ PROFESSIONAL DEVELOPMENT
National database
its hard to replicate success
locally
We need to help
teachers out

✱ TIME
for teachers to learn
not in isolation
SYSTEM + MEASURING PRODUCTIVITY
EX: Globe
(fits with science
standards)
Teachers became less active
due to new district
standards
We need alternative
measures for teachers
to make heroic effort

✱ NATIONAL goals
what are linkages
to get from where we
are now

✱ Technology
① Internet reality missed opportunities
② trying to solve real
problems
EX: here's a broken circuit.. FIX IT!
IN CLASSROOM, need
to do standards

KNOW
not
DO

✱ Is there any emphasis
placed on 2nd language
learners... immigration...
the underbelly?

Let's talk about the
underdog

✱ MEASUREMENT + ROI
– Seems like a real trap to fall into
– lack of trust in system
– hard to measure eg the right test
will shut system down more
IN OUR CORPORATION WORK AT [illegible]: we're trying to advocate its
at a different level

✱ WE VALUE FAIRNESS OVER SUBSTANCE
need social agreement of
what we value .. its a
social problem

✱ MACHINES COULD DO TESTS MUCH MORE SUBTLE
MEMORIZE vs DO IT
need a sensible
curriculum

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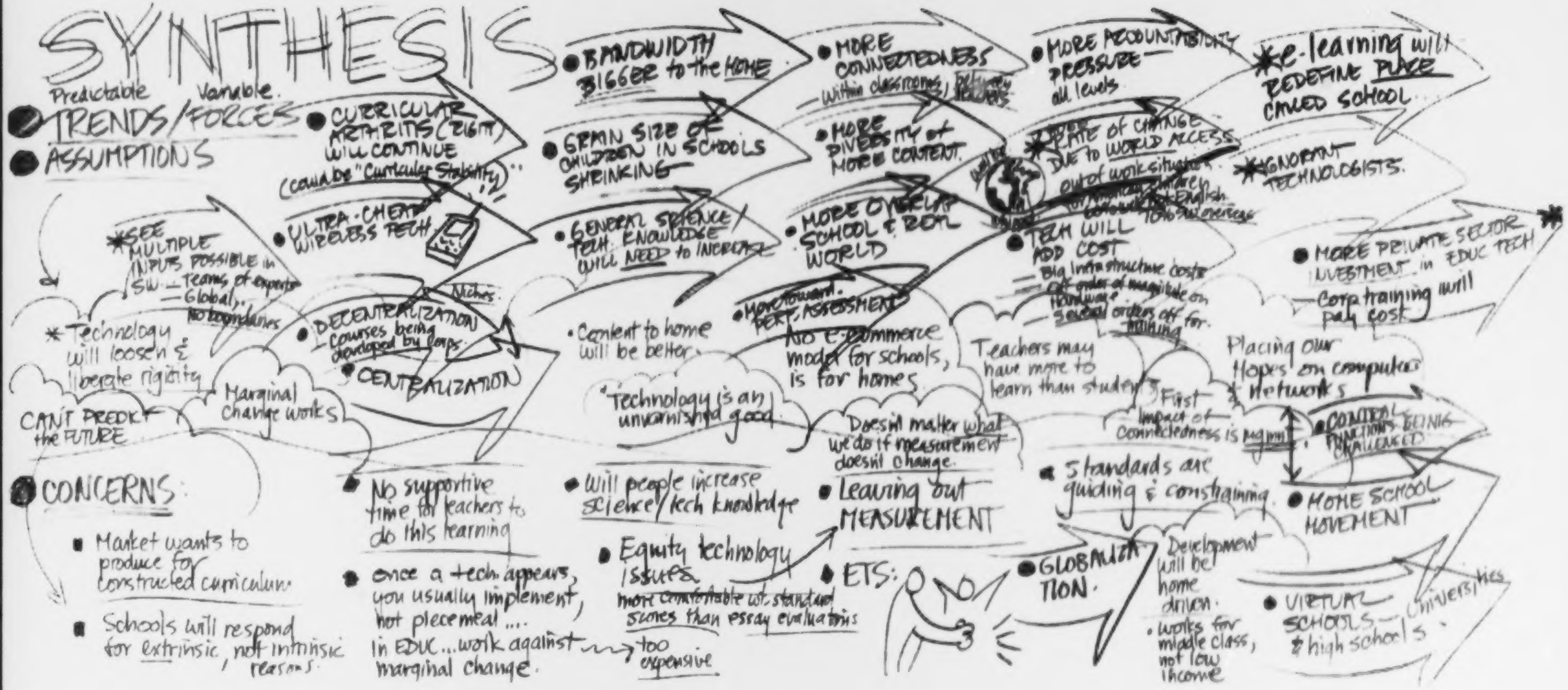
SYNTHESIS
Predictable
Variable.
TRENDS/FORCES
ASSUMPTIONS
CURRICULAR ARTHRITIS (RIGHT) WILL CONTINUE
(could be "Curricular Stability")
ULTRA-CHEAP WIRELESS TECH
*SEE MULTIPLE INPUTS POSSIBLE in SW — Teams of experts — Global, No boundaries
DECENTRALIZATION — courses being developed by corps.
Niches.
CENTRALIZATION
* Technology will loosen & liberate rigidity
Marginal change works
CAN'T PREDICT the FUTURE
BANDWIDTH BIGGER to the HOME
GRAIN SIZE OF CHILDREN IN SCHOOLS SHRINKING
GENERAL SCIENCE/TECH. KNOWLEDGE WILL NEED to INCREASE
• Content to home will be better.
"Technology is an unvarnished good.
MORE CONNECTEDNESS — Within classrooms, between teachers
MORE DIVERSITY of MORE CONTENT.
MORE OVERLAP SCHOOL & REAL WORLD
Move toward. PERF. ASSESSMENT
No e-commerce model for schools, is for homes
Doesn't matter what we do if measurement doesn't change.
MORE ACCOUNTABILITY PRESSURE — all levels
RATE OF CHANGE DUE to WORLD ACCESS
out of work situation
English
10% overseas
TECH WILL ADD COST
— Big infrastructure costs
— orders of magnitude on Hardware
— Several orders off for training
Teachers may have more to learn than students
First impact of Connectedness is minimal
*e-learning will REDEFINE PLACE CALLED SCHOOL.
*IGNORANT TECHNOLOGISTS.
MORE PRIVATE SECTOR INVESTMENT in EDUC TECH
— Corp training will pay cost
Placing our Hopes on computers & Networks
CONTROL FUNCTIONS BEING CHALLENGED
Standards are guiding & constraining.
HOME SCHOOL MOVEMENT
CONCERNS:
Market wants to produce for constructed curriculum
Schools will respond for extrinsic, not intrinsic reasons.
No supportive time for teachers to do this learning
once a tech. appears, you usually implement, not piecemeal ....
In EDUC... work against marginal change.
Will people increase science/tech knowledge
Equity technology issues
more comfortable w/ standard scores than essay evaluations
too expensive
Leaving out MEASUREMENT
ETS:
GLOBALIZATION.
Development will be home driven.
works for middle class, not low income
VIRTUAL SCHOOLS — Universities & high schools.

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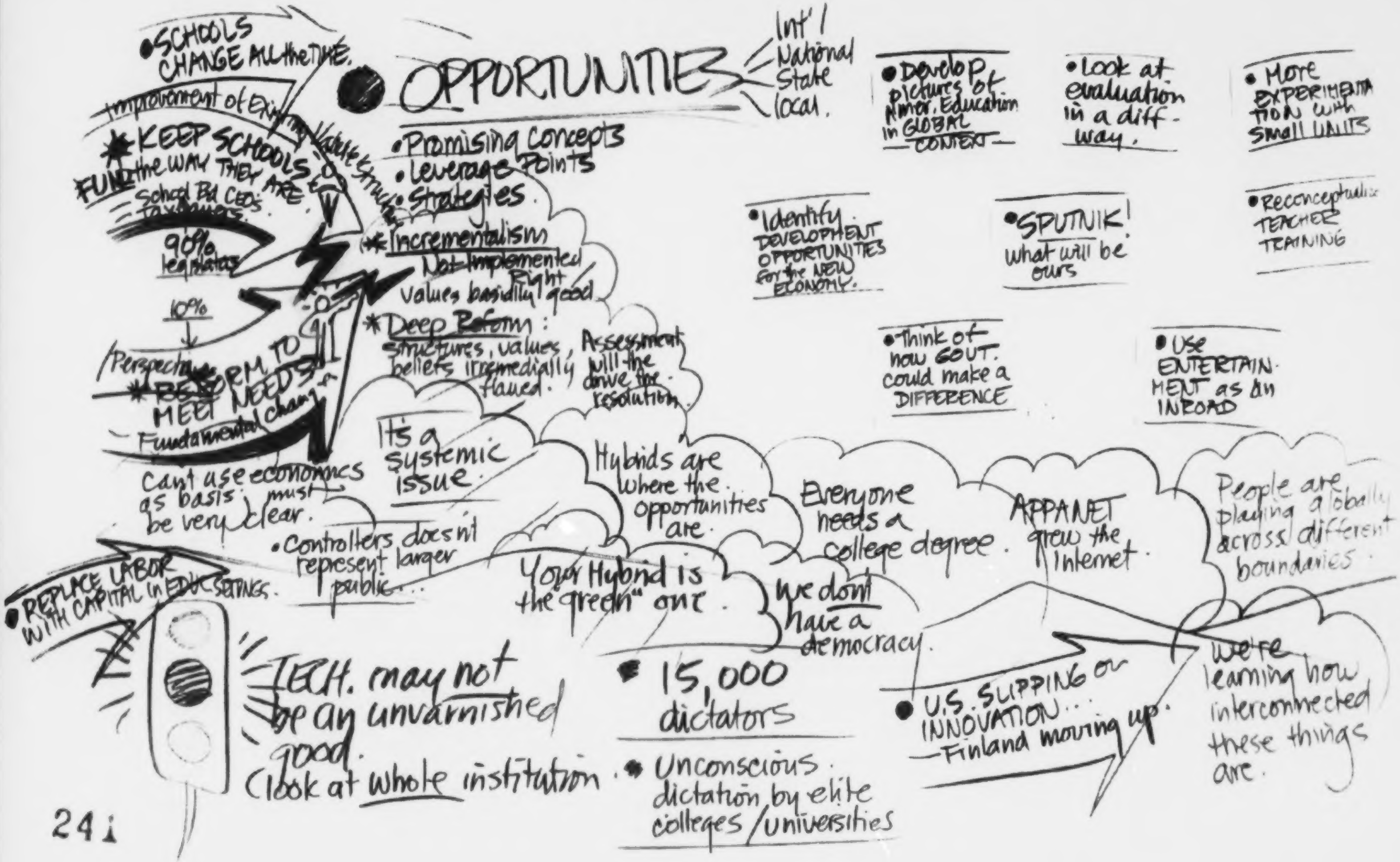

- SCHOOLS CHANGE ALL the TIME.

OPPORTUNITIES

Int'l
National
State
local.

Improvement of Existing Value Structures

- Promising concepts
- Leverage Points
- Strategies.

* KEEP SCHOOLS the WAY THEY ARE

FUND

School Bd CEO's
taxpayers.

90%
legislators

10%

Perspectives

* ~~RE~~FORM TO MEET NEEDS

Fundamental change

* Incrementalism
~~Not Implemented~~ Right
values basically good.

* Deep Reform:
structures, values, beliefs irremedially flawed.

Assessment will the drive the resolution.

Can't use economics as basis. must be very clear.

It's a systemic issue.

Hybrids are where the opportunities are.

- Controllers does n't represent larger public...

- REPLACE LABOR WITH CAPITAL in EDUC SETTINGS.

Your Hybrid is the "green" one.

- Develop pictures of Amer. Education in GLOBAL CONTEXT
- Look at evaluation in a diff-way.
- More EXPERIMENTATION with SMALL UNITS
- Identify DEVELOPMENT OPPORTUNITIES for the NEW ECONOMY.
- SPUTNIK! what will be ours
- Reconceptualize TEACHER TRAINING
- Think of how GOVT. could make a DIFFERENCE
- Use ENTERTAINMENT as an INROAD

Everyone needs a college degree.

APPANET grew the Internet.

People are playing globally across different boundaries.

We dont have a democracy.

TECH. may not be an unvarnished good.
(look at whole institution

- 15,000 dictators
- Unconscious dictation by elite colleges/universities

- U.S. SLIPPING on INNOVATION... —Finland moving up.

We're learning how interconnected these things are.

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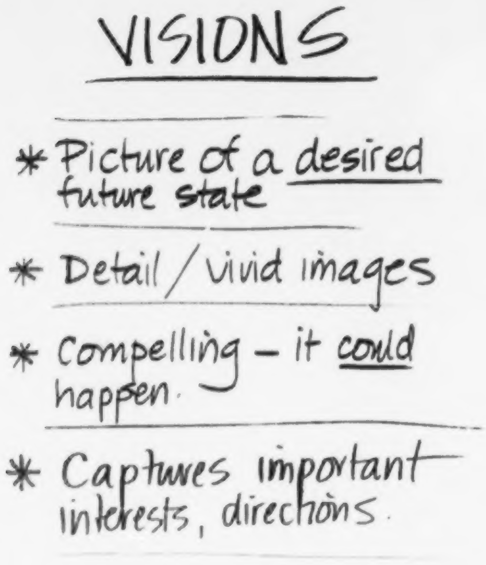

VISIONS

- * Picture of a desired future state
- * Detail / vivid images
- * Compelling – it could happen.
- * Captures important interests, directions.

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- Introduction
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- [illegible]

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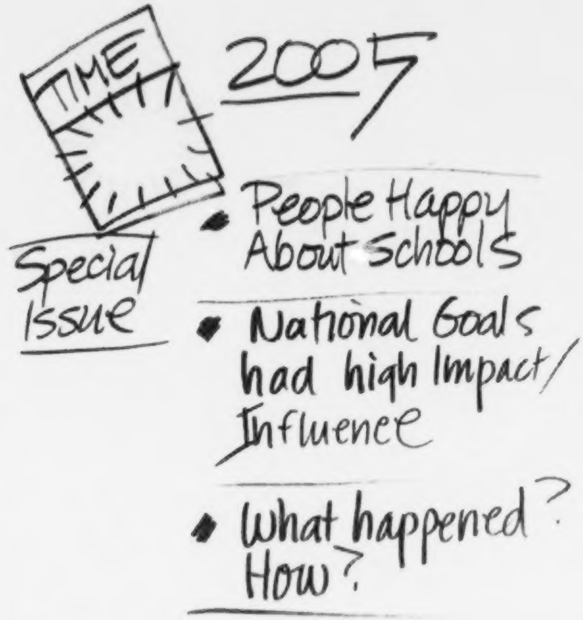

2005

Special Issue

- People Happy About Schools
- National Goals had high Impact/Influence
- What happened? How?

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- Educational Technology in Education
- Emerging Priorities
- '96 ET Plan

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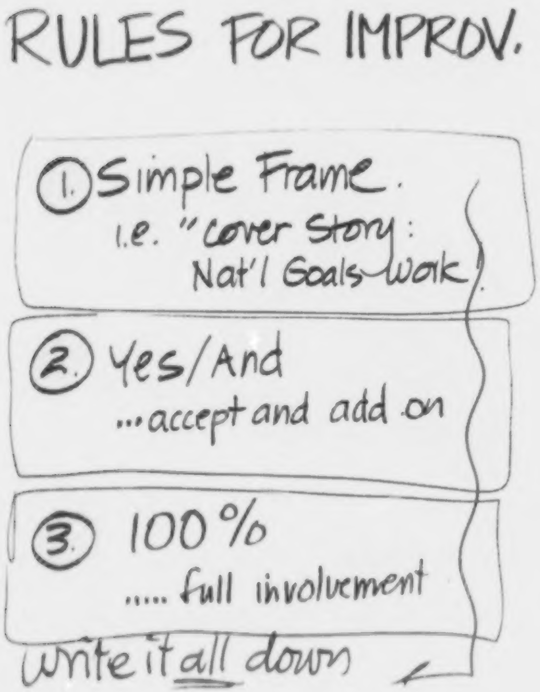

RULES FOR IMPROV.

① Simple Frame.
i.e. "cover Story: Nat'l Goals Work"

② Yes/And
...accept and add on

③ 100%
..... full involvement

Write it all down

247

248

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- White Papers
- Forum on Technology in Education
- Emerging Priorities
- 96 ET Plan

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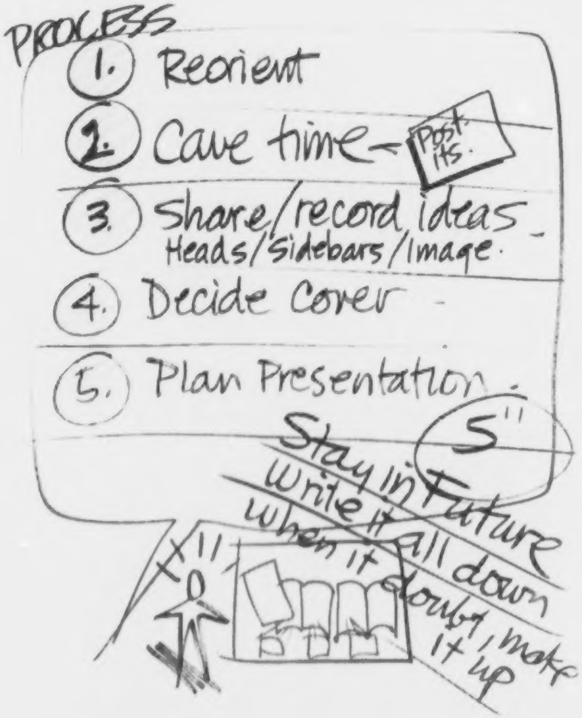
PROCESS
1. Reorient
2. Cave time – Post its.
3. Share/record ideas – Heads/Sidebars/Image.
4. Decide Cover –
5. Plan Presentation.
5''
Stay in Future
Write it all down
When in doubt, make it up

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ED HOME ED HOME

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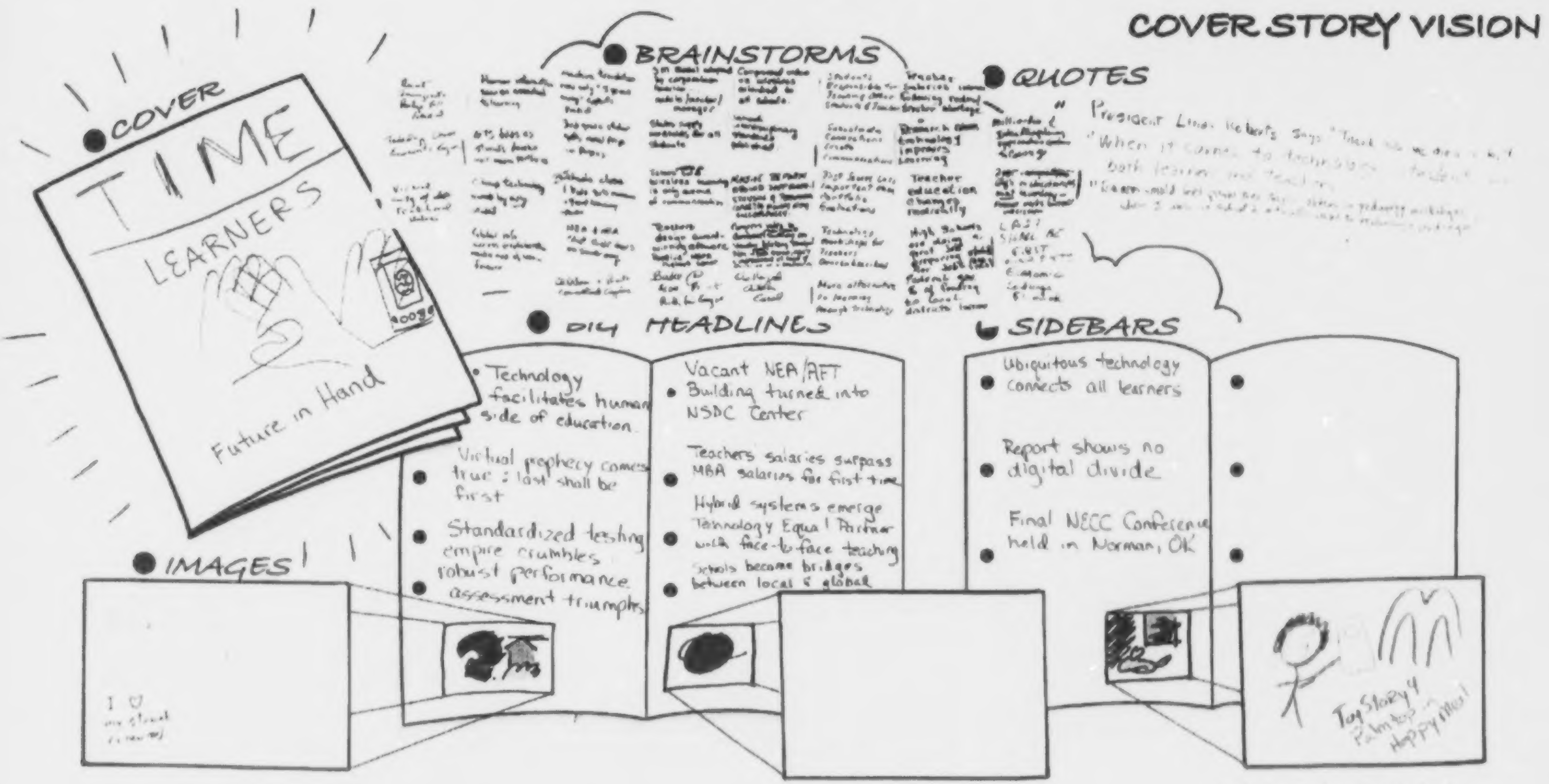
COVER STORY VISION
COVER
TIME
LEARNERS
Future in Hand
BRAINSTORMS
QUOTES
DIY HEADLINES
SIDEBARS
IMAGES
I ♡ my stroud
Toy Story 4
Palmtop in
Happy Meal

President Lin[illegible] Roberts Says "[illegible]

"When it comes to technology [illegible] both learners and teachers"

- Technology facilitates human side of education
- Virtual prophecy comes true: last shall be first
- Standardized testing empire crumbles robust performance assessment triumphs
- Vacant NEA/AFT Building turned into NSDC Center
- Teachers' salaries surpass MBA salaries for first time
- Hybrid systems emerge Technology Equal Partner with face-to-face teaching
- Schools become bridges between local & global

- Ubiquitous technology connects all learners
- Report shows no digital divide
- Final NECC Conference held in Norman, OK

"Cover Story Vision" / [illegible] 1996

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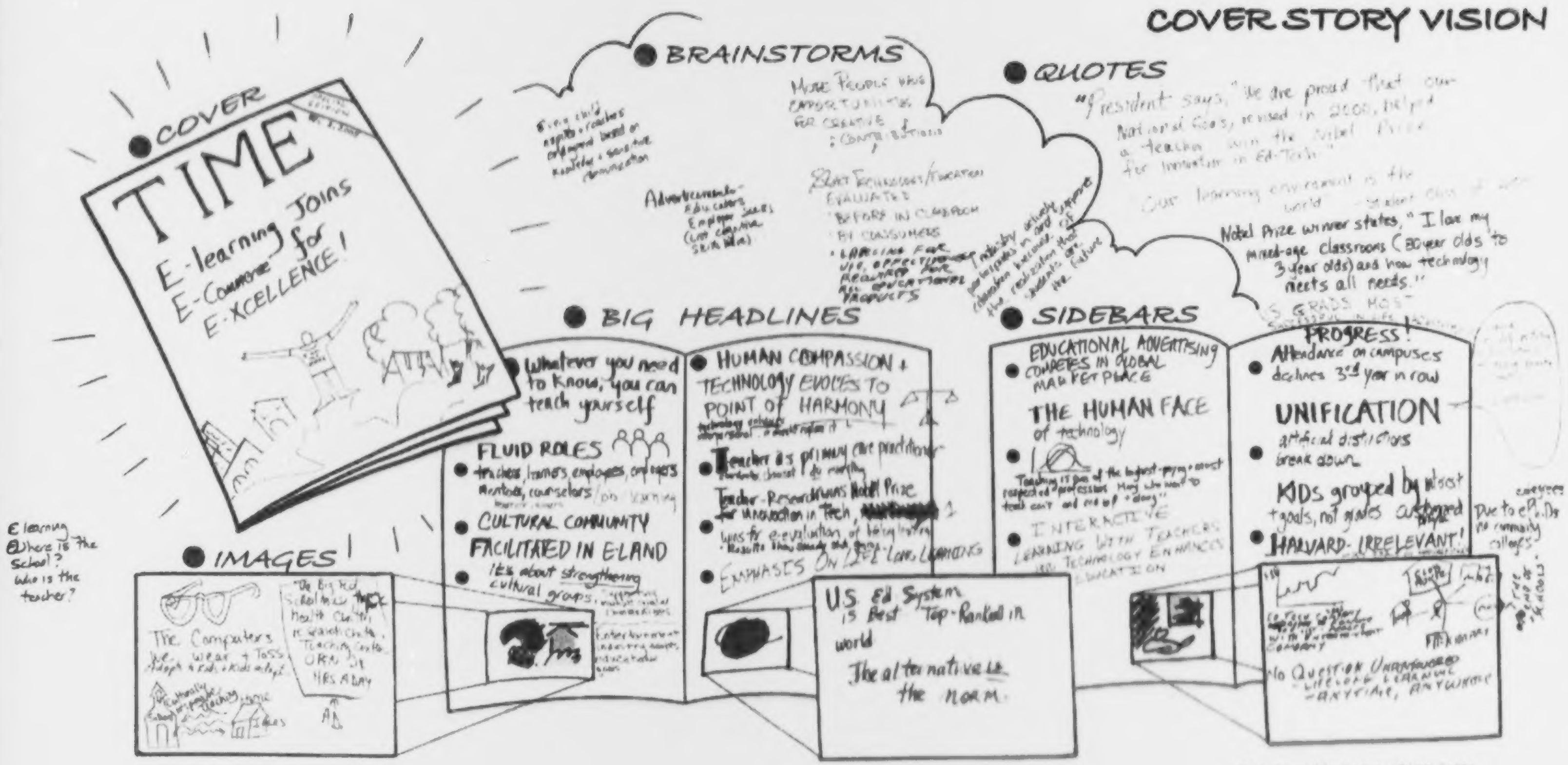
COVER STORY VISION
COVER
TIME
E-learning Joins E-Commerce for E-XCELLENCE!
E learning
Where is the School?
Who is the teacher?
BRAINSTORMS
Every child [illegible] based on knowledge + [illegible] communication
Advertisements - Educators Employer Series
More people have opportunities for creative contributions
Best technology/education evaluated before in classroom by consumers
Industry actively participates in and supports education because of the realization that students are the future
QUOTES
"President says, "We are proud that our National Goals, revised in 2000, helped a teacher win the Nobel Prize for innovation in Ed-Tech."
"Our learning environment is the world" - student
Nobel Prize winner states, "I love my mixed-age classrooms (80 year olds to 3 year olds) and how technology meets all needs."
US GRADS MOST SUCCESSFUL IN LIFE
BIG HEADLINES
Whatever you need to know, you can teach yourself
FLUID ROLES
teachers, learners, employees, employers, mentors, counselors
CULTURAL COMMUNITY FACILITATED IN E-LAND
It's about strengthening cultural groups
HUMAN COMPASSION + TECHNOLOGY EVOLVES TO POINT OF HARMONY
Teacher as primary care practitioner
Teacher-Researcher wins Nobel Prize for innovation in Tech
EMPHASIS ON LIFE-LONG LEARNING
U.S. Ed System is Best Top-Ranked in world
The alternative is the norm.
SIDEBARS
EDUCATIONAL ADVERTISING COMPETES IN GLOBAL MARKETPLACE
THE HUMAN FACE of technology
Teaching is one of the highest-paying + most respected professions
INTERACTIVE LEARNING WITH TEACHERS AND TECHNOLOGY ENHANCES EDUCATION
PROGRESS!
Attendance on campuses declines 3rd year in row
UNIFICATION
artificial distinctions break down
KIDS grouped by interest + goals, not grades
HARVARD - IRRELEVANT!
Due to ePh.Ds no community colleges
No Question Unanswered
- Lifelong Learning
- Anytime, Anywhere
IMAGES
The Computers we wear + toss
The Big Red Schoolhouse Health Center, Research Center, Teaching Center Open 24 hrs a day
School
Home

'Cover Story Vision' / [illegible] 1996

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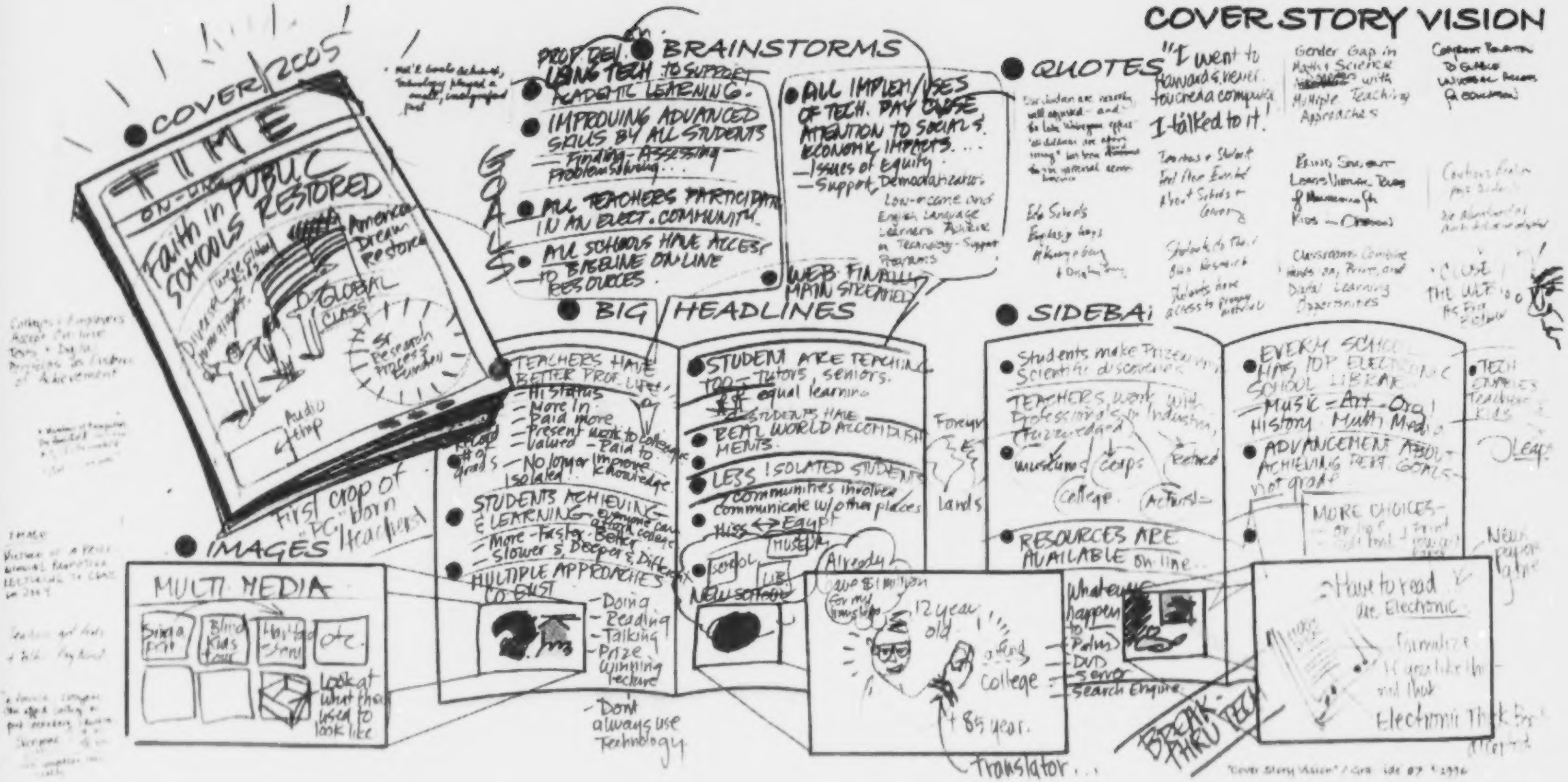
COVER STORY VISION
COVER 2005
TIME
ON-LINE
Faith in PUBLIC SCHOOLS RESTORED
American Dream Restored
GLOBAL CLASS
Research Process
Audio clip
First crop of "PC" born Headhunt
BRAINSTORMS
GOALS
PROF DEV. USING TECH TO SUPPORT ACADEMIC LEARNING.
IMPROVING ADVANCED SKILLS BY ALL STUDENTS — Finding - Assessing — Problem solving...
ALL TEACHERS PARTICIPATE IN AN ELECT. COMMUNITY.
ALL SCHOOLS HAVE ACCESS TO BASELINE ON LINE RESOURCES.
ALL IMPLEM/USES OF TECH. PAY CLOSE ATTENTION TO SOCIAL & ECONOMIC IMPACTS...
—Issues of Equity
—Support Democratization
Low-income and English Language Learners Achieve in Technology-Support Programs
WEB FINALLY MAIN STREAMED
QUOTES
"I went to Harvard & never touched a computer. I talked to it!"
Gender Gap in Math & Science with Multiple Teaching Approaches
Classrooms Combine Hands on, Print, and Digital Learning Opportunities
"CLOSE THE WEB"
BIG HEADLINES
TEACHERS HAVE BETTER PROF. LIFE
—Hi status —More in —Paid more —Present work to colleagues —Valued —Paid to improve knowledge —No longer isolated
STUDENTS ACHIEVING & LEARNING — More - Faster - Better — Slower & Deeper & Different
MULTIPLE APPROACHES CO-EXIST
—Doing —Reading —Talking —Prize winning lecture
—Don't always use Technology
STUDENT ARE TEACHING TOO — Tutors, seniors.
equal learning
REAL WORLD ACCOMPLISHMENTS.
LESS ISOLATED STUDENTS
Communities involved
Communicate w/other places
Foreign lands
School Museum Lib New school
Already
12 year old
College
85 year.
Translator...
IMAGES
MULTI MEDIA
Look at what they used to look like
SIDEBAR
Students make Prize-winning Scientific discoveries
TEACHERS work with Professionals in Industry
Museums Corps College Retired Activists
RESOURCES ARE AVAILABLE on line...
Whatever happen to Palm, DVD, Server, Search Engine
EVERY SCHOOL HAS TOP ELECTRONIC SCHOOL LIBRARY
—Music — Art — Oral History — Multi Media
ADVANCEMENT ABOUT ACHIEVING PERF. GOALS — not grade
MORE CHOICES
TECH ENABLES Teachers Kids
New paper age
Have to read the Electronic
Formalize
Electronic Think Breakthrough
BREAK-THRU TECH
"Cover Story Vision" / Graphic 07 ©1996

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- Forum Report

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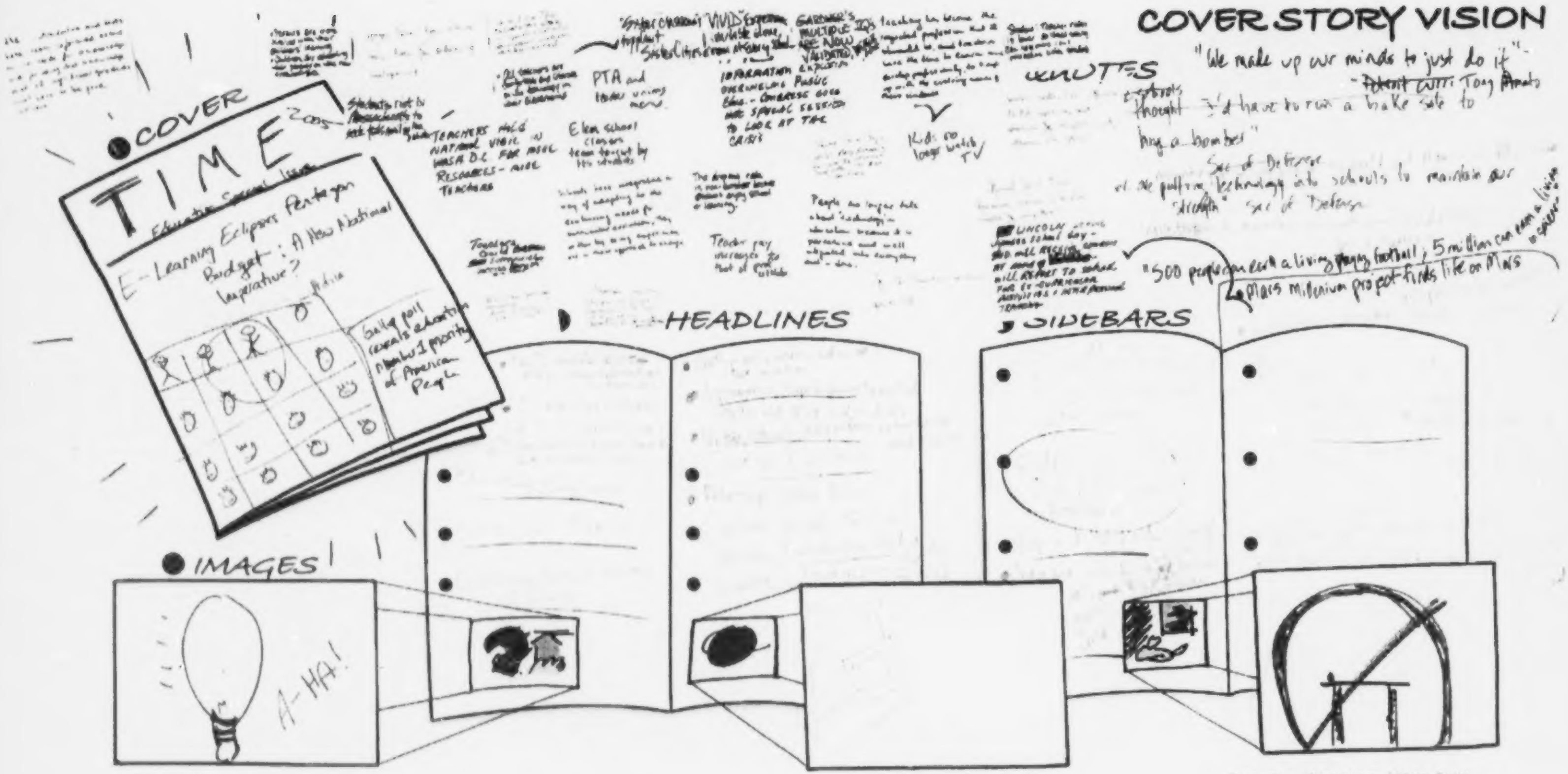
COVER STORY VISION
"We make up our minds to just do it" - ~~Potomit with~~ Tony Amato
"I thought I'd have to run a bake sale to buy a bomber" Sec of Defense
"... putting technology into schools to maintain our 'decade'" Sec of Defense
"500 people can earn a living playing football; 5 million can earn a living ..."
Mars Millenium project finds life on Mars
QUOTES
COVER
TIME 2005
Education Special Issue
E-Learning Eclipses Pentagon Budget: A New National Imperative?
Gallup poll reveals education number 1 priority of American People
TEACHERS HOLD NATIONAL VIGIL IN WASH D.C. FOR MORE RESOURCES - MORE TEACHERS
PTA and teacher unions merge
Elem school classes team taught by HS students
INFORMATION EXPLOSION OVERWHELMS PUBLIC ... CONGRESS GOES INTO SPECIAL SESSION TO LOOK AT THE CRISIS
GARDNER'S MULTIPLE IQs ARE NOW VALIDATED
Kids no longer watch TV
Teacher pay increases to that of ...
HEADLINES
SIDEBARS
IMAGES
A-HA!

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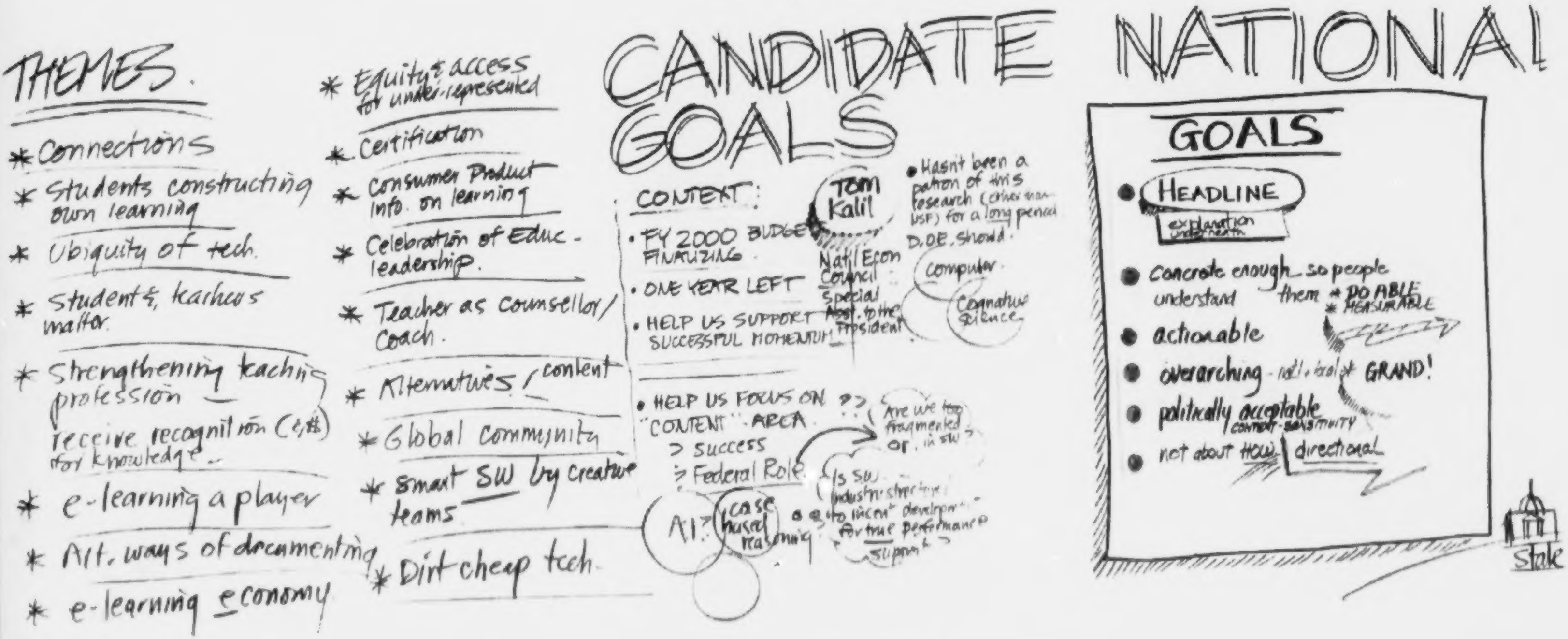

THEMES.

- * Connections
- * Students constructing own learning
- * Ubiquity of tech.
- * Student & teachers matter.
- * Strengthening teaching profession — receive recognition (¢,$) for knowledge..
- * e-learning a player
- * Alt. ways of documenting
- * e-learning economy
- * Equity & access for under-represented
- * Certification
- * Consumer Product info. on learning
- * Celebration of Educ.-leadership.
- * Teacher as counsellor/ Coach.
- * Alternatives / content
- * Global community
- * Smart SW by creative teams
- * Dirt cheap tech.

CANDIDATE
GOALS

CONTEXT:

- FY 2000 BUDGET FINALIZING
- ONE YEAR LEFT
- HELP US SUPPORT SUCCESSFUL MOMENTUM

Tom Kalil

Nat'l Econ Council
Special Asst. to the President

- Hasn't been a patron of this research (other than NSF) for a long period

D.OE. should.

computer

Cognative science.

- HELP US FOCUS ON "CONTENT" AREA
  - > SUCCESS
  - > Federal Role.

Are we too fragmented or in SW?

Is SW industry structure to incent development for true performance support?

AI? case based reasoning

NATIONAL

GOALS

- HEADLINE — explanation underneath
- Concrete enough so people understand them * DO ABLE * MEASURABLE
- actionable
- overarching - nat'l + local * GRAND!
- politically acceptable CONTENT-SENSITIVITY
- not about HOW | directional

State

ED— ED—

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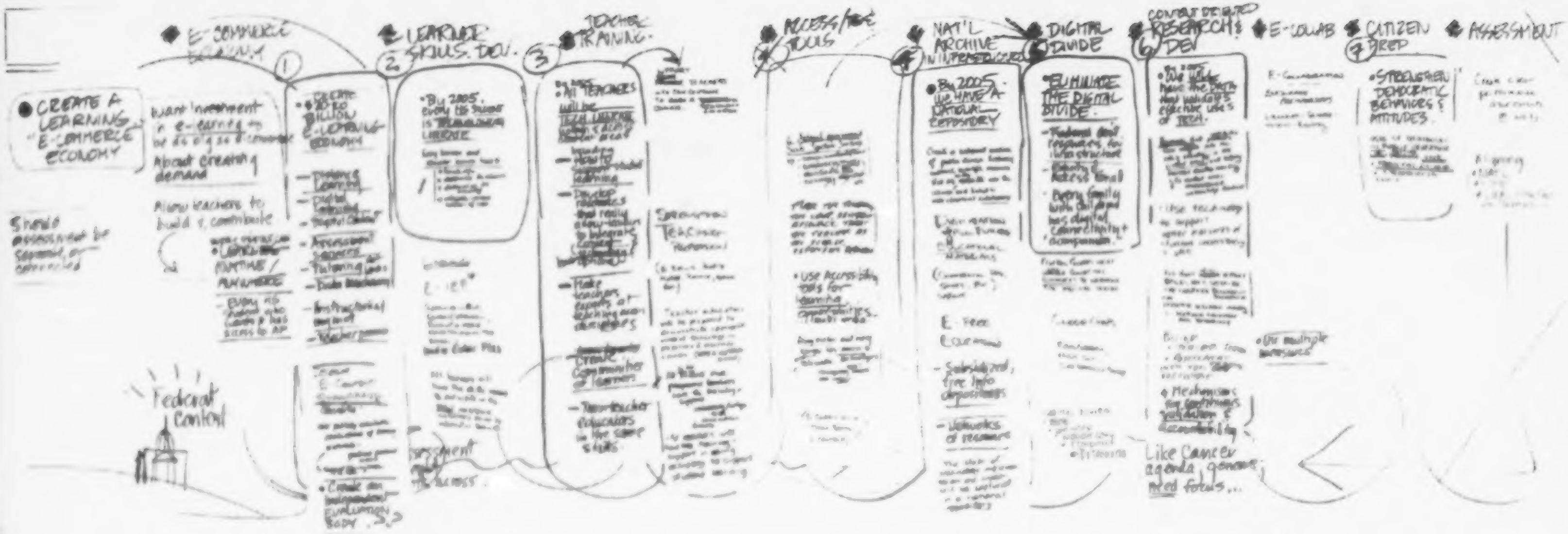
E-COMMERCE ECONOMY
①
CREATE A LEARNING "E-COMMERCE" ECONOMY
want investment in e-learning to be as big as e-commerce
About creating demand
Allow teachers to build & contribute
Should assessment be separate or connected
LEARNING ANYTIME / ANYWHERE
CREATE $20 BILLION E-LEARNING ECONOMY
Distance Learning
Digital Textbooks
Assessment Supports
Tutoring
Instructional support
Create an independent EVALUATION Body
② LEARNER SKILLS. DEV.
By 2005, every HS Student is TECHNOLOGY LITERATE
E-IEP
③ TEACHER TRAINING.
By 2005 All TEACHERS will be TECH LITERATE
Develop resources that really allow teachers to integrate
Make teachers experts at teaching across disciplines
Create Communities of learners
Train teacher educators in the same skills
Sponsored Teacher Movement
Federal Context
ACCESS/TOOLS
Use Accessibility tools for learning opportunities.
④ NAT'L ARCHIVE W/INTERPRETIVE
By 2005, we have a national repository
E-Free Education
Subsidized, free info depositories
⑤ DIGITAL DIVIDE
ELIMINATE THE DIGITAL DIVIDE.
Federal Govt responsible for infrastructure
Every family with children has digital connectivity + components.
CONTENT DRIVEN RESEARCH & DEV
⑥
By 2005 We will have the data that validates effective uses of TECH.
Use technology to support
Mechanisms for continuous validation & accountability
Like Cancer agenda, generate need focus...
E-COLLAB
Use multiple resources
⑦ CITIZEN PREP
STRENGTHEN DEMOCRATIC BEHAVIORS & ATTITUDES.
ASSESSMENT

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- Introduction
- Forum Report
- White Papers
- Forum on Technology in Education
- Emerging Priorities
- '96 ET Plan

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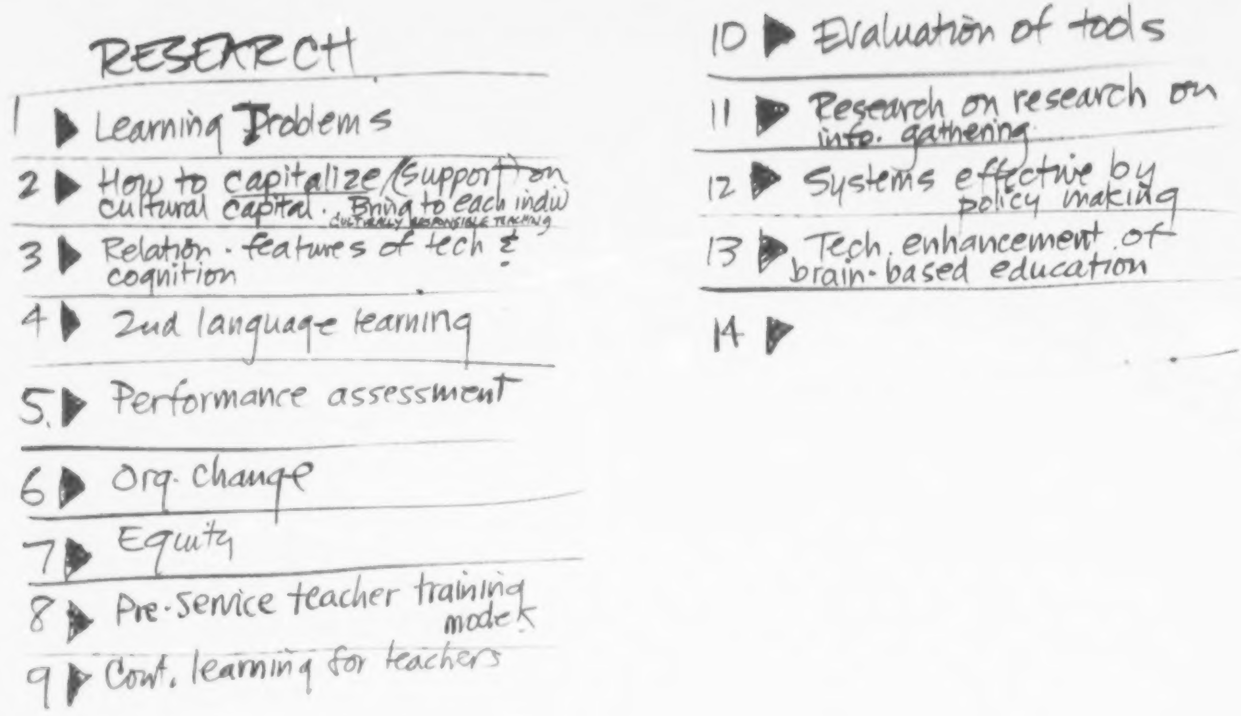

RESEARCH

1 ▶ Learning Problems

2 ▶ How to capitalize/(Support) on cultural capital. Bring to each indiv
CULTURALLY RESPONSIBLE TEACHING

3 ▶ Relation · features of tech & cognition

4 ▶ 2nd language learning

5. ▶ Performance assessment

6 ▶ Org. change

7 ▶ Equity

8 ▶ Pre-Service teacher training model

9 ▶ Cont. learning for teachers

10 ▶ Evaluation of tools

11 ▶ Research on research on info. gathering

12 ▶ Systems effective by policy making

13 ▶ Tech. enhancement of brain-based education

14 ▶

Introduction | Forum Report | Forum White Papers | Forum on Technology in Education | Emerging Priorities | Comment Here | 1996 National Educational Technology Plan

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Your Comments

Whether you are an educator, student, administrator, policymaker, parent or other family member, or concerned citizen, we are interested in your experiences with and lessons learned about the effective use of technology in the nation's schools. Your input is shaping the development of a new national educational technology plan to be released fall 2000. Summaries of on-line input can be found on this site.

Access to technology
Teachers and technology
Students and technology
Educational technology research and development
E-learning and education
Click here to view all five summaries (117K) in pdf format

"Kids Chat" with Linda Roberts, Director, Office of Educational Technology

Use the navigation wheel at the top left of your screen to view summaries of on-line input or by clicking on the appropriate link.

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Summary Reports of Comments on ACCESS TO TECHNOLOGY, TEACHERS AND TECHNOLOGY, STUDENTS, TECHNOLOGY, EDUCATIONAL TECHNOLOGY RESEARCH AND DEVELOPMENT, and E-LEARNING AND EDUCATION

Summary Report of Comments on ACCESS TO TECHNOLOGY

Background

Since the 1996 release of the nation's first educational technology plan, interest in increasing the use of technology in education has catapulted to national prominence. This interest has been spurred by the widespread recognition of the transformations technology is having on the American economy, as well as by the potential for technology to transform the teaching and learning experience. A growing sense now exists that there is a critical mass of opportunities to make tremendous strides in improving the nation's schools. In recognition of these opportunities, the Office of Educational Technology has undertaken a strategic review and revision of the national educational technology plan to be completed by fall 2000.

As part of the process of preparing the plan, the U.S. Department of Education's Office of Educational Technology is soliciting public comments on priorities for the future of technology in education, originally identified at the *Forum on Technology in Education: Envisioning the Future*. These priorities include issues related to: access to technology, teachers and technology, students and technology, e-learning, and research and development.

This report summarizes the comments received on the priority of access to technology, which were received through a website constructed for that purpose (see www.ed.gov/Technology for more information). It is divided into three main sections:

1. **Support for increased access to technology**. These comments reinforced the priority by emphasizing the need for all students to have access to technology in their schools, homes and communities.

2. **Barriers to increasing access to technology**. These comments focused on the barriers which may occur in an effort to provide access to all students and teachers, including funding resources, technical support for technology, and teacher preparedness to integrate technology into instruction.

3. **Implications for increasing access to technology.** These comments addressed issues often derived from, but not addressed in the priority as well as provided suggestions on implementing the priority as a goal.

The following sections include more specific information, both paraphrased and directly quoted, from those individuals who provided feedback.

Support for Increased Access to Technology: All Students And Teachers Will Have Ubiquitous Access To State-Of-The-Art Information Technology In Their Schools, Communities, And Homes

> *Much of the promise of the use of technology in education, including the notion of fostering learning anytime anywhere, hinges on the universal availability of learning tools for students and teachers and on their effective use. In addressing this issue, it is important to pay attention to individual learner characteristics and needs, as well as the social context of using technology.*

The following comments endorse the priority—*All students and teachers will have ubiquitous access to state-of-the-art information technology in their classrooms, schools, homes and communities*—by emphasizing the need for all students and teachers to have access to technology for education at school, home or in their communities:

> *We need to put a computer in every child's hands to use all the time.*
>
> –Administrator

The movement toward ubiquitous access is a call for all students and teachers to have the electronic support system to facilitate teaching and learning at all times, whether in the classroom, community or home. Several comments reiterated the need to see technology as a "learning support system" which should be integrated into the curriculum rather than viewed as a separate entity. One teacher wrote:

> *I look forward to the day when educators realize that technology is a tool (just like paper, pencils, books, etc.) and that all students will be expected to utilize technology in their daily lives. As educators, we need to prepare our students for what they will be expected to know.*
>
> –Teacher

Schools are following the lead of society. The skills to use information technology and the associated tools is required in many careers. Since schools are preparing students for the workforce, these skills should be taught in the educational system.

> *At this point there is a race to make the school, which is in a population boom, more connected than ever to the technological capabilities of the use of computers and the Internet. However, some areas appear to be neglected.*

Access for All

Technology in education has the potential to revolutionize teaching and learning, however many students and teachers in the most needy schools and communities have the most limited access to state-of-the-art technologies.

> *Access to the technology for anytime/anywhere learning needs to be assured at all socio-economic levels. It is imperative that a techno-caste system not be developed.*
>
> –Researcher

> *The distance between the technological proficiency of students and teachers with access to technology and those who have limited or no access is continually widening. Students and teachers from economically depressed urban areas and especially those from rural areas represent a tremendous segment of the population that is grossly underserved as far as access and acquisition of technology is concerned. In an increasingly competitive global economy, we cannot afford to NOT assure access to the technologically disenfranchised.*
>
> –College/University

Home Access for Teachers And Students

There is increasing discussion about providing anytime, anyplace opportunities for learning for both students and teachers. For students, many argue that in-class access to technology is not sufficient. Students perform higher when they have home access to computers and the internet. A teacher said, *the children NOT having home access to web-based delivery will be at a distinct disadvantage.*

In addition, many of the existing programs that allow students to take computers home encourage children to allow family member to use the device as well. Thus, home access for students oftentimes provides the benefit of increased family involvement. One teacher commented:

> *There must be provision for student access to technology away from the school. Those families who can not afford equipment must be provided with a means of accessing internet equipment. Some school systems provide Internet devices that students can take home for access.*
>
> –Teacher

Home access for teachers was a concern also raised by several respondents. Clearly stated by a respondent from the Association for Supervision and Curriculum Development,

> *As the professionals charged with exposing our children to responsible uses of information technologies, schools and districts are irresponsible NOT to provide teachers with state-of-the-art equipment and access, as well as ongoing professional development focused on their use in the context of the curriculum. Access to these resources should not be confined to the school building; teachers should have at least the same level of access to which we aspire for our children in their role as learners and healthy, active citizens.*

Community Access

Community resources, such as public and school libraries and community technology centers, also play a major role in providing for access to technology for families who do not have home access. A respondent from the American Library Association wrote:

> *Public libraries are the number one point of access to the Internet for students who do not have access at home or after school. With more and more schools connecting their classrooms to the Internet, perhaps the more important role of the public library is as the number one source of Internet access for adults, including parents, who do not have access at work or home.*

In addition,

> *Libraries offering training in Internet use are seeing over-subscription to courses & waiting lines for use. The educational impact on the community cannot be denied.*

For example,

> *The Alabama Virtual Library hosted by the Alabama Public Library Service is a prime example of the type of content access that should be encouraged. Any Alabama resident from a public school or with a public library card can access eight licensed databases: EBSCOhost, Electric Library, Encyclopedia Britannica, FirstSearch, Gale Literary Resources, Grolier Online, Proquest and SIRS Knowledge Source.*

Barriers to Increasing Access to Technology

The following comments raised issues that have, and potentially will serve as obstacles to an effort to provide access to all students and teachers, including identifying and soliciting funding resources, addressing the need for technical support for technology, and fully preparing teachers to integrate technology into instruction.

Funding

> *Availability ultimately hinges on available funding.*
>
> –Administrator

Funding for educational technology is a real issue regularly faced by teachers, administrators, state and federal government officials. Although funding has increase dramatically over the past several years, students are still deprived from optimum access to even modern equipment because of program funding constraints. One desperate teacher wrote:

> *Currently we have wonderful access in our school, however, being a very poor district, only one-fourth of our students has access at home. We have tried to open our libraries in the evening and found it to be very successful, but now no longer have the funding to do this. Our students need to have computer and internet access evenings and weekends as well as during the school day!*

Even if funds are available, many respondents still viewed receiving educational technology funding as a very political process. One administrator wrote of convincing local boards of education to provide sufficient funding in order to fill the schools with adequate technology, while another respondent wrote:

> *If we are to realize this vision of universal availability for all teachers and students, assistance must be afforded us on both the state and federal levels. Systems such as ours can ill afford the hiring of grant writers to give us the edge with competitive grants. We need funding that looks at all aspects of our situation and doesn't depend on how well we write a grant!*

Other respondents emphasized that when requesting funding for technology it is not sufficient to only address the cost of computers and wiring.

> *Each district must use their technology coordinators and other stakeholders, and create a plan of what technologies to put into the school district. This needs to include, computers, printers, software, professional development, and as importantly as all others, network wiring, structure, and maintenance.*
>
> –Administrator

> *Computers are no good without software, and without professional development programs which are structured to teach teachers how to creatively and effectively use computers and other technologies in their classrooms.*
>
> –Administrator

Technical support for technology and preparing teachers to integrate the technology into the curriculum are two areas that respondents were concerned by the current level of support for. These areas have been barriers for the respondents, and may continue to be without full support for funding in these areas.

Technical Support for Technology

With the rapidly increasing supply of computers in the schools, there has been a realization that technical support for technology in the school districts and schools is essential to the effective integration of technology in the classroom. Many school districts did not plan for such a need, thus in quite a few cases unqualified teachers and support staff are responsible for maintenance or qualified staff are overburdened.

> *We can do so much more with what we have, if school systems had the resources to adequately support technology. An "all-encompassing" technology plan must include recommendations for support personnel. These personnel must not be teachers or others who have taken it up as a "hobby", but trained, qualified technology professionals. People with experience, higher education and industry training. Personnel trained in desktop support and repairs, server support and repair, and end-user support / training.*
>
> –Other, MI

I don't want to comment necessarily on access, rather support, which enhances access. The state funding, which is based on national standards, for computers needs to outline the importance of maintaining the equipment in place.

–Administrator

Teacher Preparedness to Integrate Content Rich Uses Of Technology Into Instruction

> *Access and training must go hand-in-hand. Funding for training of teachers needs to be required.*
>
> –Other, TX

Teachers must be appropriately trained to integrate educational technology for effective use. However, teachers often feel uncomfortable with their knowledge of computers and software. Thus, as a student suggested:

> *Universal access is an excellent goal, but needs as a pre-requisite, teachers TRAINED in the use of the technology. Access is good. Good Content to access is better.*
>
> –Student

One respondent called for a national effort to require the training of teachers.

> *It should be a national mandate that schools must provide the training for teachers and students must have computer skills to graduate. Left to the individual schools, many will never appropriate the funds to train teachers or make sure students are prepared for the world they face in the future.*

Implications for Increasing Access to Technology

The following comments addressed issues that have the potential to affect the implementation of the priority as a national goal as well as provided suggestion for policy consideration in the implementation of the priority as a national goal.

> *The key factors that allow school libraries to provide access to state-of-the-art technology are training for the library media specialist and funding for hardware, software, Internet access, and database subscriptions. School administrators and boards of education must appreciate the importance of access to information technology in order to support its growth in their districts.*

Equity in Access

Although this priority pertains to providing ubiquitous access for al teachers and students, very few respondents addressed how to attain it. One respondent praised the wording of the priority, but said that this effort had not yet begun to address the *central issue of accessing needed funds to ensure that all students have ubiquitous access.*

However, the comments of one teacher model the national support that will be needed to institute a system for providing access to all students and teachers.

> *The only answer to this problem which is emerging is to guarantee ubiquitous access, perhaps modeled after our phone services, and perhaps funded as our school lunch*

> *programs. Without such support in place, we will create unequal access to education as it is evolving now.*
>
> –Teacher

Use/Content-Driven Instruction

> *The focus should not be on student/teacher access at all. The focus should be on what is to be done with that access.*
>
> –Administrator

A concern raised by many respondents is that access is only the first step. In addition, students and teachers need to be prepared to use technology effectively through content-driven instruction.

> *Simply put, students and many educators "do" technology. In other words, the use of technology is some that we "do" when we get that hour's worth of lab time per week. Or it's something that we get to "do" when we are finished with other work. Incorporation? Integration? In many classrooms situations, these concepts do not exist.*
>
> –*College/University*

One college/university respondent commented that *the perception that because schools are "wired" automatically means that integrating technology takes place is real, yet sadly flawed.*

The concept of integrating technology into teaching and learning will change the way many view the educational system. One responded wrote t*eachers are going to need to re-vamp their "mind set"* to fully achieve the potential of technology in the classroom.

Another respondent felt that greater understanding of the importance of technology integration into the curriculum at the school district level would affect the classroom.

> *I feel my school district does not really understand the importance of teachers using computers to teach. They feel that having a computer in everyclassroom is the answer not just a small start. I do not know exactly how to convey to them all that is avaiable. Do you have any suggestions? I think they would be willing to listen.*
>
> –Library

Increase and "Incentify" Involvement

The public and private sectors contribute greatly to the furthering of technology in education. However, several respondents included suggestions for increasing their involvement. As suggested in the following comment, the public sector may support increased funding of technology for education when tangible benefits for the whole community are seen.

> *It is my belief that the political will to provide access for students and teachers will come if that access is part of an overall effort that has benefits for the entire community.*

Private investment and participation in technology for education has been an essential source of funding. In addition to monetary investments, it was suggested that business actively participate in moving the technology industry forward as to provide the tools needed in education. One administrator suggested that we *"incentify" business to develop low-cost, wireless, modem-equipped devises for both teach and student so that all can access data/information.*

Responsible Access

Increased access to technology leads to the potential for access to inappropriate information. A few respondents expressed their concern about unsuitable material that students access through the web. For example,

> *We have found in our school district that students are setting up web-based email accounts. Many of these are inappropriate due to the spam and content that passes through our filters in this way. We have difficulty controlling this.*
>
> –Administrator

On the contrary, another respondent was concerned about using filtering programs to limit the access students have to improper information.

> *As a long time public school teacher, librarian and administrator, I'm concerned that "ubiquitous access" means access only to those materials that someone thinks students should access. In extensive tests on filtering products, over and over again it has been determined that sites filtered are chosen as much for their political opinions as their sexual or violent ones. Students who are never allowed to make significant decisions in the confines of school and home will be unprepared to make such decisions when confronted with the whole spectrum of world opinion when they are adults.*

Another respondent addressed this issue by stating that it should be the charge of education to prepare students to responsibly make these critical decisions about information.

> *While many children have access to electronic resources at home and in their communities, it is our responsibility in education to equip them with the critical, analytic, and organizational thinking skills to make effective judgments and responsible use of the information to which they have access using electronic resources. Our charge also includes preparing healthy, active adults for their roles in society.*
>
> –Other, Association

Acceptable Level Of Technology

A few respondents questioned the recommendation for "state of the art" technology in schools as stated in the priority. One respondent wrote:

> *It is "fashionable" to suggest that teachers and students should have access to "state of the art" computer and other IT facilities. I think that is a silly thing to suggest. Many researchers and many other employees do not have access to "state of the art" facilities. What is needed is that students and teachers have access to facilities that are sufficiently modern so that they can readily be used to accomplish the tasks for which they are intended.* –Other, ISTE (may want to take this out)

However, even many modern technologies do not provide the level and speed of access needed in the school setting. The following is a description of one teachers class experience with technology that limited her class activities:

> *Access to technology is improving, however, it is far from ideal. We have access to the internet but it is so slow that it is not productive for the classroom where a number of students are trying to do research. Our lab serves about 15 students. We might be able to get about half of these on line and working at moderate speeds but to get the full class on is near impossible. Our connection is still based on 56K phone line access. I'm sure there are many schools still operating at this level, which is better than none but not adequate to really involve students to any great degree.*
>
> –Teacher

Summary Report of Comments on TEACHERS AND TECHNOLOGY

Background

Since the 1996 release of the nation's first educational technology plan, interest in increasing the use of technology in education has catapulted to national prominence. This interest has been spurred by the widespread recognition of the transformations technology is having on the American economy, as well as by the potential for technology to transform the teaching and learning experience. A growing sense now exists that there is a critical mass of opportunities to make tremendous strides in improving the nation's schools. In recognition of these opportunities, the Office of Educational Technology has undertaken a strategic review and revision of the national educational technology plan to be completed by fall 2000.

As part of the process of preparing the plan, the U.S. Department of Education's Office of Educational Technology is soliciting public comments on priorities for the future of technology in education, originally identified at the *Forum on Technology in Education: Envisioning the Future*. These priorities include issues related to: access to technology, teachers and technology, students and technology, e-learning, and research and development.

This report summarizes the comments received on the priority of teachers and technology, which were received through a website constructed for that purpose (see www.ed.gov/Technology for more information). It is divided into three main sections:

4. **Support for teacher use of technology**. These comments reinforced and elaborated on the priority by emphasizing the need for teacher professional development.

5. **Barriers to teacher use of technology**. These comments addressed potential barriers and obstacles that must be resolved before all teachers can be considered technologically literate and effective users of technology.

6. **Implications for teacher use of technology.** The final set of comments addressed issues that have implications for setting any priority involving teachers and technology.

The following sections include more specific information, both paraphrased and directly quoted, from those individuals who provided feedback.

Support for Teacher Use of Technology: All Teachers Will Effectively Use Technology

> *There is universal support for devising ways to encourage teacher use of technology aligned with instructional goals whether delivered through preservice education or inservice professional development or both. Given the continual changes and advances in technology, the need for training is ongoing and must not only be about how to use technology, but also about how to support student learning.*

As the role of technology in our everyday lives grows, the importance of integrating technology in education becomes increasingly important. Individuals who submitted comments about the priority of increasing teacher use of technology emphasized the tremendous value and benefits of a teacher's use of technology in teaching:

> *Our district is striving diligently, particularly our campus to become technologically literate and supplied with the necessary teacher tools and student workstations.*
>
> -Anonymous commentator

In recognition of this, a high priority has already been placed on integrating technology into a teacher daily curriculum. For example, state-level training programs are being developed and implemented in order to achieve this goal. Some who commented noted that Georgia and Texas each have training programs that focus on in the integration of technology in the classroom. Both programs, 'In Tech' and 'Tech Certification Training', received high praise from teachers that had participated in these training programs.

Indeed, some teachers have already experienced significant success when implementing technology into their curriculum. One teacher from Texas reports her achievement in a Title 1 school with 90 percent of the children enrolled in free and reduced price lunch programs:

> *I have had great success with utilizing my antique computers to achieve a form of interactive writing. First grade students are just beginning to learn to read and write, and are highly motivated to learn when given proper support. I use the shared pen technique (adult uses one color of ink and the student uses a different color) to teach the children to write. The student is able to illustrate and color his work on the computer. Because the final product is written correctly (corrections in the teacher's color), the student is then able to read his work as well. I collect each student's writing in a folder called "___'s Red Storybook." The children take these home each night to read to their family. Progress from the beginning to the end of the year is quite evident and everyone loves the "Red Storybooks".*
>
> -Teacher, Texas

Another administrator from Oklahoma proudly reports on the success of one of her teachers in using the Internet in an English class:

> *Teachers when given the opportunity and tools necessary to use technology in their classroom are very innovative. One of our English teachers....had her 11th grade students make web pages for the different scenes in Macbeth.*
>
> -Administrator, Oklahoma

A Florida administrator had great praise for his technology coordinator who:

> *...gets the parents involved, and is one of the best users of a wide range of technology that we have ever seen.*
>
> -Administrator, Florida

Barriers to Teacher Use of Technology

As teachers struggle to adopt technology and integrate it into their curriculum, several barriers are confronted in doing so. Contributors mentioned several barriers that they felt were significant in prohibiting them from achieving the goal of making effective use of technology. Most comments centered around five central issues:

- Teachers' fear of technology,
- The large amount of time required for training,
- The high cost of training,
- The lack of technical support,
- Lack of administrative support, and
- Proper implementation of technology into the curriculum.

Teachers' Fear of Technology

One barrier is the attitudes teachers have towards adopting technology. The comments submitted seemed to indicate that many teachers still find technology intimidating. Due to this fear, many teachers currently do not make use of technology in their teaching. The following comments elaborate on this issue:

> *It has been a frightening experience for some of our teachers. It is hard for some of our veteran teachers to give up the old standards of teaching. Few of our teachers have seen actual classrooms that are integrating technology successfully into the curriculum. Most of them think it is too time consuming to try to prepare lessons using technology. Our teachers need a program that trains them in the use of technology in the classroom.*
>
> -Technology Coordinator,
> Georgia

> *Teachers need to have a role model for technology use. They need to see the benefit of what technology can do for them in their classroom use. They even have to be pushed into seeing and trying new ways of teaching. Teachers become isolated in their classrooms. Technology should be something that opens up the world to them*

and their students. Instead many of them are fearful that technology will replace them, that technology will fail them, that they will appear stupid in front of the students, and that technology will go away like many other educational fads.

- Anonymous commentator, Texas

The goal of teachers and technology usage seems to be missing the essential element of integrating technology into instructional practice. The mere addition of technology will produce little if teachers are not using technology as a means of instruction. The technology should be seen as a tool for learning, a means of learning and a way to allow students to "construct" their own knowledge. This shift in thinking will not occur over night and will not be accomplished by the addition of resources alone in the classroom.

-Teacher, Tennessee

There must be a clear connection between technology and its support of student learning and standards or teachers will focus on other areas for their staff development.

-Administrator, New York

The Large Amount of Time Required For Training

In addition to the attitudes that some teachers have towards technology, the large amount of time required for training is also a barrier to the use of technology. Many teachers must spend long hours in training to become competent in the use of technology which sometimes is required in addition to their regular teaching duties. The following comments emphasize some of the frustration felt about this issue:

Teachers, more than any other professionals are burdened with many societal and structural changes in their jobs. Nothing, it seems, is solid or standing still in education. Seeing that they have access to training and "staff development" is not enough. This access must be provided at times that suit the dedicated professional who must work many hours and raise a family, as well as be a CONSTANT LEARNER.

-Teacher, New York

In order for teachers to effectively use technology to enhance student performance, teachers must be provided the release time to participate in meaningful professional development activities that will provide them with the skills necessary to seamlessly integrate technology into all curricular areas.

-Administrator, Georgia

> *Until teachers are given more time to develop skills with technology, the use of technology in educational settings will continue to lag behind true potential. To effectively use technology with students to teach curriculum objectives, teachers need in-depth training with follow-up support and continued mentorship with experts. The investment must be much greater and more concentrated than it has been in the past. This is critical for the future of our young learners.*
>
> -Teacher, Washington, DC

> *Teacher training for use of technology is crucial and so is providing time and incentive for practicing the skills learned. So often skills are taught then teachers are expected to know how to use the skills immediately with students. Time for exploration and practice is needed for proficiency. The practice time is virtually never provided.*
>
> -Teacher, Texas

> *The findings show that teachers (or anyone else) need to be involved in and given resources for adapting technology. Time is documented as the single most persistent barrier to change for teachers. Without this resource, there is little hope except for those technologies that speed up logistics, such as copiers, records, and email.*
>
> -Administrator, California

The High Cost of Training

Individuals who have gone on to get further training in technology typically find that the cost of such training is high and the compensation low. Therefore, comments submitted indicate that trained staff is hard to find and attrition is a significant problem.

> *I am now teaching teachers to use computers..., but I am being forced out of this field because my school loans total $594.00 a month on a gross salary of $42,000.00. Those of us who are desperately needed in the field to be training teachers are also in high demand in industry at much higher salaries. If the government could designate these types of positions (technology trainers, coordinators, teachers on special assignment – technology) as shortage areas and forgive loan debt for years of service, then we could afford to follow our hearts and continue to support and train classroom teachers in the use of current technologies.*
>
> -Technology Teacher,
> Colorado

> *I teach full time...for Title One, a federally funded reading program. I am wondering why school districts such as ours do not fund enough tech people to keep the computer systems in our schools running. ...My suggestion is that school systems budget easily 10 percent or even more for technical support.*
>
> -Teacher, Colorado

> *Schools, especially high schools, will continue to have problems with trained staff as long as (1) there is a high rate of turnover among staff...*
>
> -Teacher, Kentucky

The Lack of Technical Support

Some individuals reported that they do not feel like they have enough support in their efforts to implement technology. Such support is viewed as essential to the smooth operation of a technology in schools, but many teachers find that they have little or no technical support at hand. A librarian reports her problems with lack of good technical support:

> *Teachers must have technical support if they are going to use technology. The machines must work as dependable as a chalkboard ... otherwise teachers will be forced to use the chalkboard .... Keeping technology operating properly is a part of the cost of the technology. Let's see some standards or expectations regarding such things as: number of technical support persons per teacher, number of system failures, response time for tech support, total downtime, and availability of back-up equipment. Businesses expect performance from the electronic equipment they purchase...time is money in the business world. The "teachable moment "is even more valuable.*
>
> -Librarian

Lack of Administrative Support

Lack of administrative support was another issue brought up by individuals that submitted comments as a large barrier to achieving teacher use of technology. Commentors indicated that administrative support for technology is sometimes superficial or unenthusiastic about technology. The following comments were submitted on the issue:

> *The need for change in both the academic regimen and the utilization for technology is acute. However, change is both dreaded and unwelcome. There seems to be a great effort to "show" that some form of community building is going on (i.e. site-based management) but in reality, the superintendent and/or principals still make the final decisions. Also, there is an effort to "show" that technology is greatly used (i.e. technology plans), but in reality technology is hindered by administrators who either refuse to use a computer or view it only as a word processor.*
>
> -Technology Coordinator,
> Texas

> *We have many teachers who have, or are currently receiving training, but find it difficult to implement their newly developed technology goals due to the fact that some principals are not as enthusiastic about technology as the teachers. Therefore, the principals do not support the acquisition of hardware and software for teacher/student use, and do not allow time for technology maintenance exploration. Principals who do not embrace technology are often the "speed bumps" that teachers encounter along the road to integrating technology into the curriculum. I believe that some principals need to be encouraged to partake in professional development which addresses the integration of technology into the curriculum, and school districts need to provide the technical support that teachers and principals need to move forward.*
>
> -Teacher, Pennsylvania

Proper Implementation of Technology into the Curriculum

Several comments were made addressing the fact that in order for teachers to make effective use of technology. Comments suggested that technology must be implemented into the curriculum in a constructive manner or it will be an ineffective tool in teaching. The following comments describe their feeling on this topic:

> *There seems to be little attention being paid, in the grand scheme of things, to integrate technology and teaching in pedagogically appropriate ways, as opposed to integration for its own sake. If a particular technology does not fit with the curriculum, choose another, or don't use it at all.*
> *While it is a step in the right direction, for example, (in the sense of gaining familiarity with technology and attempting to integrate in the classroom) to use a Power Point presentation in the classroom, that cannot be viewed as the end of the road. It's still just another form of passive instruction - teacher at the front, students sitting listening.*
>
> -Administrator, Oregon

> *E-education is fast evolving in both technology and what is being delivered. The half-life makes the Mayfly's life seem long. We still seem to think of teachers and schools and classrooms in a world that is wired and the teacher could be in Djibouti and the student at home. We need to think of technology as more than a pencil or a desk in a single space- a room with students and a teacher. Our current visions are extrapolist and very costly in more than money. We need to craft a vision of education and what the new roll of an educator will be before we try to just paste technology onto the schools and a teacher training program like a badly executed collage.*
>
> -Anonymous, Minnesota

> *....it is essential that time and resources be directed toward creating an understanding of the process of how technology can support student learning... i.e., the cognitive processes that are fostered by technology and methods of harnessing and directing those processes in the most productive ways to benefit students.*
>
> -Administrator, New York

> *The quality of education must be evaluated separately from the medium. The medium is only the delivery system...not the REASON for education. Technology-based education delivery systems should be held to the highest standards for providing knowledge and skills. Institutions need to provide faculty with ongoing comprehensive internal training to assist with quality control issues in technology.*
>
> -Researcher, Texas

> *....the statement misses the point that both preservice and inservice teachers need to have a deeper level of information technology knowledge, so that they can think beyond merely using the IT to achieve the current (rather traditional) goals of education. While the Teachers and Technology statement does not explicitly say so, my feeling is that it has a strong focus on use of IT to preserve the status quo in educational content.*
>
> -Anonymous, Oregon

> *Knowing how to use technology is no guarantee that instructors will apply that knowledge and actually use technology in their teaching. After all, lots of faculties know how to word-process. But, except for producing some handouts, faculties (outside of some English courses) do not tend to incorporate word processing directly in their classroom teaching activities. Knowing how to use the Internet does not mean a teacher will employ the Internet in a course.*
>
> -Anonymous, California

Implications for Teacher Use of Technology

> *...software without adequate training and time to practice their new skills is useless. Software and training must go hand in hand.*
>
> -Anonymous, North Carolina

The implications that can be drawn from the comments on teacher use of technology all point towards the relevance of adequate training. Training, both pre-service and inservice were emphasized as a high priority in the accomplishment of the goal of teacher efficiency using technology. Ideas were also raised that a teacher might be able to put technology to use as a means of professional development. Another suggestion was to have a trained professional in each school specifically designated to handle the technology needs. The suggestions made therefore centered around four central issues:

- Preservice Training,
- Inservice Training,
- The use of technology for professional development, and
- A trained technology specialist for every school

Preservice Training

It is noted that many teachers are still in need of substantial professional development in this area and several individuals had strong views about this issue. The following comments indicate the importance that was made about proper training at the preservice stage:

> *It should be a national mandate that all schools provide teacher training in technology. If teachers are ever going to use current technology and move forward, we need to give them the training and support they need to embrace technology. All students training to be teachers should have to take several technology courses. I am amazed at how many teachers come straight from college and have such few technological skills. Our universities need to make radical changes so these students are prepared to use technology on a daily basis.*
>
> -Teacher, Pennsylvania

> *Teacher's effective use of technology begins in the preservice programs. Most institutions offering teacher preparation programs offer a variety of courses addressing technology and information resources, but most of these courses are separate from the "core" teacher prep curriculum, and many are optional for the teaching degree or certification. If information resources are to be used effectively by teachers, for both administrative and teaching tasks, then instruction about those resources must be presented as a part of an integrated teacher preparation program. The program must include expectations within all areas of study that the teacher candidate will be familiar with and competent using a variety of technologies, able to identify, access and use effectively information resources and to be able to convey the value of information resources to their future students.*
>
> -Anonymous, Virginia

Inservice Training

Inservice training was noted to be of particular importance for teacher, especially for those who had been in the profession for several years. It was noted that such teachers had particular problems in adopting technology and training these teachers was of particular importance. The following remarks were submitted about importance of inservice training:

> *I've been in this business for 35 years and have preached that teacher preparation is the key to successful utilization of technology in the classroom. Unless schools of education change the way they teach (e.g., modeling the use of technology in their own teaching), and school districts get serious about ONGOING teacher training & support we will miss a real opportunity to elevate the education of our children.*
>
> -Professor, New York

> *...I don't think professional development in technology should be optional. It should be mandatory. A teacher who is overwhelmed with training and workshops will choose professional development that interests her. There are MANY teachers who are not interested, or who need extensive training but are not seeking it out by choice. All the hardware and software that money can buy won't do the students one bit of good unless the teacher is confident and competent with technology. Technology proficiency should be mandatory.*
>
> -Teacher, New York

> *Districts must put in place a comprehensive plan to train teachers in the use of the latest technology. This training must be mandatory...This training should be included in the college level of teacher preparation classes.*
>
> -Anonymous, Oklahoma

Use of Technology for Professional Development

Comments submitted suggested that technology can be used for the professional development of teachers. The idea that teachers could use technology to learn from each other and share information. The following comments describe two current methods of providing professional development through technology:

> *The Teachers and Technology priority statement acknowledges the need for "training" to use technology, but does not mention the role that technology can play in providing teachers with access to professional development opportunities and to communities of colleagues who can provide support for developing new skills. As professionals in other professions know, training is only the first step in developing facility and expertise with technology. Support from one's community of practice is essential for the lessons learn in training to be put into practice on a sustained basis.*
>
> -Researcher, California

> *Our program... supports a teacher-to-teacher network that links technology-using teachers to others who want to learn.... finds teachers who have developed exemplary classroom practices that integrate technology to meet our state standards, then publishes their work so that others around the state may access funds to try those same ideas in their classrooms. Eight years of evaluation show this approach works - new teacher-users trust other teachers much more than "experts," and also learn ways to integrate technology into their work with students.*
>
> - Anonymous, Maine

A Trained Technology Specialist in Every School

One comment submitted suggested that every school should have a trained technology specialist:

> *In each school, a certified School Library Media Specialist should be one of the primary information and technology professionals. School Library Media Specialists receive graduate level education in seeking, evaluating, and organizing information in all media, including electronic and Web-based materials. They are also trained specifically to teach these libraries and information research skills to students and teachers at all skill levels. The teachers who are taught how to take advantage of the skills of these professionals are the teachers who will most efficiently achieve expertise in effectively using technology in their own teaching activities.*
>
> *In many of the most technologically advanced schools the School Library Media Center is the hub for technology access and is the center for learning to make the most of such access.*
>
> -Anonymous, Washington, DC

In sum, the comments submitted indicated that while some teachers were already effectively making use of technology in their curriculum, there were other teachers that were not able to make effective use of technology. Some training courses are already being implemented with positive results but there are still barriers that exist. The barriers cited ranged from the fact that some teacher feared technology, there was a lack of time to acquire adequate training, the cost of training was high, to a lack of both technical and administrative support. To resolve the problem many people indicated the more adequate training was necessary at bot the preservice and inservice stages. A lot of emphasis was put on the fact that such training should be mandatory for all teachers. Whether or not mandatory preservice and inservice training would address all of the perceived barriers is not clear but it could certainly go a long way towards breaking some of them down.

Summary Report of Comments on STUDENTS AND TECHNOLOGY

Background

Since the 1996 release of the nation's first educational technology plan, interest in increasing the use of technology in education has catapulted to national prominence. This interest has been spurred by the widespread recognition of the transformations technology is having on the American economy, as well as by the potential for technology to transform the teaching and learning experience. A growing sense now exists that there is a critical mass of opportunities to make tremendous strides in improving the nation's schools. In recognition of these opportunities, the Office of Educational Technology has undertaken a strategic review and revision of the national educational technology plan to be completed by fall 2000.

As part of the process of preparing the plan, the U.S. Department of Education's Office of Educational Technology is soliciting public comments on priorities for the future of technology in education, originally identified at the *Forum on Technology in Education: Envisioning the Future*. These priorities include issues related to: access to technology, teachers and technology, students and technology, e-learning, and research and development.

This report summarizes the comments received on the priority of students and technology, which were received through a website constructed for that purpose (see www.ed.gov/Technology for more information). It is divided into three main sections:

7. **Support for student use of technology**. These comments reinforced and elaborated on the priority by emphasizing the need for students to become technologically savvy—capable of locating, evaluating, and interpreting information individually.

8. **Barriers to student use of technology**. These comments addressed potential barriers and obstacles that must be resolved before all students can be considered technologically literate and responsible cybercitzens.

9. **Implications for student use of technology.** The final set of comments addressed issues that have implications for setting any priority involving students and technology.

The following sections include more specific information, both paraphrased and directly quoted, from those individuals who provided feedback.

Support for Student Use of Technology: All students will be Technologically Literate and Responsible Cybercitizens

> *Today's world is marked by increasingly rapid, social, political, and technological change – change that is becoming increasingly more difficult to predict. As a consequence, in addition to being academically, socially, and emotionally prepared, students will need to be technologically savvy—understanding how to locate information, determine its, relevance, determine its accuracy, and integrate it with other sources.*

> *Given the rapid growth of technology and the changes taking place in the workforce, the skills and knowledge students will need for future success are changing as well. Students must be able to think critically and analytically, recognizing when they lack knowledge about something and how to obtain the needed information. Proper incorporation of technological tools with their coursework will not only assist students with learning and improve the learning environment, but also better prepare them for the road ahead.*

> *The following statement reinforces this priority:*

> *Students' "work" in our country's education system is not confined to memorizing facts, decoding text, and providing correct responses for standardized tests. They are preparing for their roles as adults in an increasingly complex, global community. To navigate that community successfully, students must receive, as a component of their education, a thorough grounding in the responsible use of information resources. This grounding includes their exposure to a variety of technologies, and making connections between information needs and the use of these technologies as one component of effective problem-solving....This deliberate integration of information resources into all areas of the curriculum allows students to apply essential e-skills to tasks that will influence their health, their happiness, their productivity as working adults, and their impact as citizens.*
>
> —Individual from a national education association

Indeed, students across the country are using various computer programs to enhance their educational experience. As one teacher states:

> *Our students use Microsoft Office '97 to do class reports using Word, Excel, and PowerPoint. They do video editing using computer software to assemble group projects into PowerPoint presentations. The students use Internet sources to do research and obtain class resource materials.*
>
> —Teacher, Tulsa, Oklahoma

The statement below reflects on where we are:

> *It is very clear that we can learn in a manner which is more efficient than our current models indicate. Some education systems have effectively cut learning times and increased comprehension. Technology clearly points to our inadequacies in addressing opportunities. Additionally, the wired world opens learning venues outside the traditional school for all learners K-gray.*
>
> —Editor, Minneapolis, Minnesota

Another comment elaborates on the need for all individuals to be able to successfully access and evaluate information, namely health information.

> *Having the abilities to access and evaluate health information is no longer an option; it is essential for all citizens. A healthy citizenry, especially now that we live so much longer, is crucial to our national interest. The price--in money, in esteem, in longer work-lives--of ignorance and lack of savvy is too high to allow us not to adequately prepare all citizens.*
>
> —Individual from Oregon Health
> Sciences University

Barriers to Student Use of Technology

Comments regarding barriers to achieving the priority can be divided into two categories: those addressing obstacles to achieving "technological literacy"—knowing how to access, evaluate, and integrate information efficiently and effectively and by so doing add to one's educational prowess—and those addressing the issue of becoming a "responsible cybercitizen"—using computers for constructive purposes as opposed to destructive and detrimental ones, and proper computer maintenance.

Technological Literacy

The following set of comments address technological literacy and issues that must be addressed and resolved before this part of the priority can be achieved.

> *While it is wonderful to enhance curricula with technology, I am finding an increasing number of children (K-12) who come to the library expecting instant answers to homework questions with the click of a mouse button. Study skills and the like do not seem to be taught anymore, as well as the important "book or computer" issue- discerning which to use and how to incorporate them for an assignment. Kids are expecting the Internet to do their homework for them now....**schools have to do more than just plug computers in the wall.***
>
> —School librarian

Now that a majority of schools have access to computers and are connected to the Internet the next step to further enhancing and improving the educational environment for students is to ensure adequate use of this technology. Placing computers in classrooms will not miraculously produce "technologically savvy" students.

> *Access to connectivity is of little value if students do not have the essential research skills necessary to move through the information available to them.*
>
> —Individual from Texas Education Agency

Furthermore it is still important for students to know how to obtain information in traditional ways, from books and periodicals, recognizing when to use these resources as opposed to the Internet.

> *...it is important to be computer literate and be able to access information from numerous sites, but students depend solely on the Internet when researching papers–there are still other resources that contain valuable information such as books, periodicals, and encyclopedias.*
>
> —Teacher, Flemington, NJ

Now that a majority of schools have access to computers more attention must be devoted to what students are actually doing with these computers and how teachers are integrating technology into their classes. Teachers need help in developing their curriculum and ensuring that it aligns with previously developed standards. One teacher praises the recent publication produced by ISTE's, National Education Technology Standards for Students.

> *The new ISTE document "National Education Technology Standards for Students" (the NETS document) places the major goals stated here in a nice context, in parallel with the Standards. I bought one for each building in a district I support, and used it to focus our teachers on this very question – when to introduce specific literacies and in what sequence, in order to lead our students to become responsible cybercitizens... This document is a winner.. get one to every teacher, maybe with the help of NEA and AFT as a membership incentive or some such plan.*
>
> —Teacher, Syracuse, New York

> *School administrators, teachers, and other educators must be cognizant of the changes that need to take place in classroom organization, curriculum development, and the relationship between teachers and students as technology becomes an integral part of school curriculums.*
>
> *New technology-focused courses must be developed in order to prepare students to cope with the wealth of information increasingly available through technology sources.* ***Most students can locate information, but few are prepared to assess relevance and accuracy; tasks previously performed by instructors and handed to students.***
>
> —Researcher, Nacogdoches, Texas

Furthermore, while it is essential to provide teachers with proper training in the use of technology it is not their responsibility alone to produce technologically literate students. All adults should encourage, support, and assist students with using technology.

> *The first obstacle to this goal is that most adults in society, teachers included, cannot satisfy this requirement themselves. It will be difficult for students to become digerati without a) good modeling by adults b) good training from skilled teachers and c) support and reinforcement of good behaviors from adult role models.*
>
> —Student, University of Northern Colorado

The following two quotes acknowledge the important role of a school librarian in assisting students with technology.

> *As technology becomes ubiquitous it will be increasingly important for students to become not only technologically literate, but also information literate. School Library Media Specialists have a strong professional background in teaching both of these important skill sets, but they are perhaps uniquely qualified to teach the later.*
>
> —Individual from the American

Library Association

> *The role of both the library and the librarian must be tied to curriculum content. Library and research skills taught in isolation are almost useless.*
>
> —Texas Education Agency, Austin, Texas

Responsible Cybercitizens

The second set of comments dealt with barriers to creating "responsible cybercitizens." These issues addressed concerns such as correct and acceptable computer usage versus misuse of networks that can potentially be quite harmful.

One school is addressing this issue by the following means:

> *...our district-wide filters block many attempts at misuse and the requirement that teachers be present during school use and that permission forms be on file from parent/guardians is our attempt to keep our students safe and on task. All net sites that are attained but are deemed inappropriate are reported immediately to the technology staffers at our central offices of technology so as to block those sites.*
>
> —Anonymous commentator

Another issue to be aware of is highlighted in the quote below.

> *Not only must integration of technology-based information be taught, but also the means to avoid the temptation to taking advantage of the ease of plagiarism provided by technology-based information sources.*
>
> —Researcher, Nacogdoches, Texas

Additionally, given the ease and agility with which students learn to use computers they may also be quite helpful with providing technical support to teachers and other school staff and trouble shooting problems as they arise.

> *Their* [students] *use of technology seems easy and they adapt well to new technologies. However, I have seen much mistrust of students with technology by the same people putting computers into the schools. The administration and teachers do not generally trust the students. I have seen acceptable use policies disseminated without getting student input first....Many schools now have training for computers such as Microsoft and Cisco, yet the schools do not take advantage of this knowledge at their campuses. I believe schools will make much more progress by learning to trust students with technology.*
>
> —Individual from Midland School District, Texas

IMPLICATIONS FOR STUDENT USE OF TECHNOLOGY

As this priority continues to be evolve, those who shared their comments noted additional issues that need to be considered. Some of these issues were addressed earlier in this summary. For example, more attention should be devoted to what students are doing with the computers and how teachers are incorporating technology into their curriculums, ensuring that it is indeed improving the learning experience for students.

Furthermore, several comments addressed the important role of the librarian in teaching computer-based research skills, which has been overlooked. Not only will the role of the librarian need to be revisited, but the role of other adults in assisting with the incorporation of computers in daily class-work, should also be considered. Teachers cannot be expected to meet all the demands placed on them alone.

Another individual expressed concern about what is not mentioned under this priority and should be incorporated:

> *This...statement....is too narrow. It leaves out the whole idea of students learning to be independent, self-sufficient, lifelong learners who know how to learn from available aids such as the Web. Learning to learn, and learning to learn from resources other than the teacher, should be one of the major goals in our educational system.*
>
> —Individual from Oregon State

Additionally, as technology continues to advance and expand we need to ensure that it is and remains usable by everyone. Some students may indeed have access to computers and a variety of programs but be unable to use them due to a learning disability. Having a computer and being able to access the Internet become meaningless if students lack the ability to actually use the vast array of resources at their fingertips. Therefore:

> *The use of assistive technology to access the conventional technology that is being used in classrooms is essential for student success.*
>
> —Assistive Technology Specialist,
> Santa Barbara, California

Summary Report of Comments on EDUCATIONAL TECHNOLOGY RESEARCH AND DEVELOPMENT

Background

Since the 1996 release of the nation's first educational technology plan, interest in increasing the use of technology in education has catapulted to national prominence. This interest has been spurred by the widespread recognition of the transformations technology is having on the American economy, as well as the potential for technology to transform the teaching and learning experience. A growing sense now exists that there is a critical mass of opportunities to make tremendous strides in improving the nation's schools. In recognition of these opportunities, the Office of Educational Technology has undertaken a strategic review and revision of the national educational technology plan to be completed by fall 2000.

As part of the process of preparing the plan, the U.S. Department of Education's Office of Educational Technology is soliciting public comments on priorities for the future of technology in education, originally identified at the *Forum on Technology in Education: Envisioning the Future*. These priorities include issues related to: access to technology, teachers and technology, students and technology, e-learning, and research and development.

This report summarizes the comments received on the priority of research, development, and evaluation which were received through a website constructed for that purpose (see www.ed.gov/Technology for more information). It is divided into the following two sections:

1 **Progress to Date: Current use of technology in education**. These comments reflect on current uses of technology in classrooms and the impact these technologies have had on students thus far.

2 **Future directions: Research, development and evaluation in educational technology.** These comments address future research, development and evaluation that should be explored in the areas of professional development, curriculum integration and student learning, and technology management and planning in schools.

The following sections include more specific information, both paraphrased and directly quoted, from those individuals who provided feedback.

Progress to Date: Current Use of Technology in Education

As the use of technology in education becomes more commonplace, it becomes critical to understand what we are learning about what works and what does not. Too often individual schools and districts are left without good information that could guide them in making appropriate investments in technology – investments that could result in tremendous changes to the educational experience for both teachers and students.

There is little doubt that technology is changing the nature of education and, when used properly, improving the learning experience for students and teachers across the country. Most individuals, whether they be educators, researchers, parents or policymakers now support the use of computers and other technologies in the classroom to enhance the quality of education. Although more extensive research is still needed in order to answer some critical questions concerning the effects of technology on student achievement, studies and observations thus far have demonstrated some initial successes.

The following individual has more than ten years experience working in residential special education schools. Based on his experience he feels that:

> *Students respond extremely well to the ease and simulation provided by the various technologies available in the classroom. I saw students who were 3-4 grade levels behind their age group able to gain ground and move to* [the next] *grade level because of the technology. These students enjoyed making something so they found motivation to improve their reading skills so they could improve the product they created….I look forward to the future where my son will have excellent teachers and excellent training.*
>
> —Parent, Ayer, Massachusetts

Another important advantage of using computers for instructional purposes is their conduciveness to "learning-by-doing:"

> Computers using e-probes and special software programs have become main stream tools for doing inquiry-based science. This equipment and software allows us to learn science by doing science not just learning about it in some textbook.
>
> *—Teacher, Tulsa Public Schools, Tulsa, Oklahoma*

The following quote refers to an innovative software program assisting with the integration of science education and technology thereby promoting higher-order thinking skills and problem-solving.

> [This] program provides middle and high school students an interactive way to explore scientific phenomena, not readily available to the classroom. The students work utilizing problem-solving strategies to create models of scientific concepts.
>
> *—Student, Technology UGA, Athens, Georgia*

Knowing how to use computers is essential to future success, as stated by the teacher in the quote below:

> *Those who know computers will be in the forefront of our society!*
>
> —Teacher, Tulsa Public Schools, Tulsa Oklahoma

Future Directions: Research, Development, and Evaluation In Educational Technology

Numerous studies have shown that technology, when used appropriately results in increased student motivation, retention, and engagement and, in some cases, has demonstrated improved student learning as indicated by standardized test scores. With proper teacher training, planning, and an adequate number of functional computers, technology can have a positive impact on student achievement. However, more extensive research into how technology should be used to enhance student learning and achievement, and the exact nature of the impact technology is having on students and teachers, is still needed. Additionally, placing computers in schools without supporting and assisting teachers in the classroom with computer usage, maintenance, and curriculum integration will not produce desirable results.

> The future of education is an appropriate link between teachers and technology. Teachers need education and training to be better able to prepare students for the world that awaits them.
>
> *—Parent, Ayer, Massachusetts*

The following section summarizes comments made about the direction of future research studies in the area of professional development, curriculum integration and student learning, and technology management and planning in schools.

Professional Development

The following comments emphasize the need for quality professional development and the important link between professional development and positive student outcomes. Professional development should consist of more than just instructing teachers in basic computer applications. Proper integration of computers with current curriculum content should also be emphasized and incorporated into professional development activities.

> ...Sufficient time needs to be set aside for staff-development...not on software alone, but on best practices of technology integrated into the curriculum.
>
> —Teacher, Salem-Keizer Public Schools, Salem, Oregon

Furthermore, technology should be viewed as a means to improving teaching and enhancing the learning environment. Placing computers in schools and providing connectivity alone will have little, if any, effect on student achievement.

> *....It is time that all people involved in the use of technology understand that teaching is not a matter of hardware. Teaching is a matter of how that hardware is used. Millions of dollars sunk into wiring schools will not do any good unless we understand that teachers have to teach. Technology is no more than a tool that can be used as easily as previous technology (VCR, movie projectors). We need to make sure that technology supports standards, assessment, and good teaching practices.*
>
> *—Individual from Fennimore, Wisconsin*

Additionally, an adequate amount of time should be allotted for participation in various professional development opportunities:

> *My biggest concern is the time needed to teach teachers. I cannot expect them to incorporate technology in their classrooms until they have been given adequate paid time during their instructional day to learn how to do this. So often I hear them being told that they need to do more internet searches, or use lesson plans found on the Web, or have their students do powerpoint presentations, but until they have the time to be trained, only those whose personal life allows before and after school training will be willing to move forward in technology.*
>
> —Individual from Westview Elementary, Lee's Summit, Missouri

Curriculum Integration and Student Achievement

Now that a majority of schools have access to computers and are connected to the Internet, the next step is to ensure that the technology is effectively integrated into the curriculum. The following individual proposes some areas for the focus of future research studies:

> *There is* [a] *need to investigate links between technology and existing programs in schools that have been successful in forging literacy and other skills. Trials should be initiated to examine the feasibility of a restructured curriculum. Such a curriculum that is thematically based yet interdisciplinary in focus, would help build more meaningful associations between areas of knowledge that students acquire.... technology-related research should focus more on equity issues related to the nature of teaching and student learning in poorer versus more affluent schools.*
>
> —Teaching Matters, Inc, Brooklyn, New York

Furthermore, in addition to collecting information on the number of computers in schools it is becoming increasingly important to examine curriculum integration approaches in schools across the country and changes in classroom structure and school organization in order to identify some best practices in this area. There is an increasing desire among educators and researchers to identify the most successful programs and the reasons for their success.

More research needs to be conducted to identify the best methods of instruction using various educational programs and software:

> *Some monies have been made available for exploring the impact on student learning in informal and formal learning environments. Additional research needs to be conducted to determine optimal methods of instructional scaffolding, design issues of software (many are still beta versions), and impact on student learning.*
>
> —Student, Instructional Technology, UGA, Athens, Georgia

Public television stations are also contributing to the development of technology-based educational programs as well as conducting research on the delivery of instructional materials via television. Through the establishment of development forums for new technologies and partnerships with research facilities public television is contributing to school reform efforts. Following this summary are the comments submitted by the Association of Americas Public Television Stations (APTS) regarding public television and their current role in educational research and development.

The following individual comments upon developing a way to demonstrate how the use of technology is affecting student achievement:

> *We still must come up with something to justify the dollars we are spending. My position has always been that highly technologically savvy teachers will change instructional practices, and they will have an impact on achievement, but how to quantify this has always been a question on my mind.*
>
> —Administrator, Hartford County Public Schools, Bel Air, Maryland

Overtime, multiple-choice tests will be replaced with other types of measurement to determine student achievement:

> *....Evaluation programs can be used with computers and can place more importance on the analysis and critical thinking processes. Performance based assessments will replace multiple-choice tests.*
>
> —Teacher, Tulsa Public Schools, Tulsa, Oklahoma

TECHNOLOGY MANAGEMENT AND PLANNING IN SCHOOLS

Technology management and planning is key to developing a successful technology program. Both individuals cited below stress the importance of planning for the integration of technology into the curriculum and developing adequate professional development activities to make the most use of available hardware and software. Too often schools fail to plan ahead and do not devote adequate time to determining how they are going to use the new technology available to them and the best means for implementation.

> *Planning provides effective management of present resources and future acquisitions, while setting realistic goals that can be assessed and measured. Some schools have been able to write such things into their Comprehensive Educational Plans and Scope and Sequence, and have thus, provided accountability for these technology goals. It is as simple as the old saying,* ***"If you fail to plan, you plan to fail."***
>
> —Teacher, Teaching Matters, Inc., New York City

> *...schools are eager to enter the technology era. They have obtained hardware and software put them into the classroom and even hired professional developers in hopes that it would create miracles. However, due to the lack of research and planning many of the computers that have been purchased and placed in the classrooms but have not been turned on. The Board of Education needs to research educational systems where technology is working and then plan how they can bring some of the ideas back and incorporate them here into the New York educational system. This will include hardware, software and training so that it will be used to enhance educational development.*
>
> —Professional developer, Teaching Matters Inc., New York City

Additionally, in planning for technology integration the following question should be considered:

> *How can technology be used to create life-long learners? Children who will grow up with the ability to infer and problem-solve. This is what should guide purchases, whether they be software or hardware. It is not important to have the fastest and most state-of-the-art if they are not used.*
>
> —Teacher, Salem-Keizer Public Schools, Salem, Oregon

Another important component of planning is accounting for, and allocating money towards technical assistance – an area that has been somewhat overlooked.

> *One of the most common mistakes/problems with technology that is currently in schools is a severe lack of adequate tech support. If the computers don't work, what good are they?.... Some areas have even forgotten to budget for tech support, meaning that computers will sit there until overworked repair people have a chance to look at them.... Computers may be good resources for teachers and students, but they have to be functional to do this job.*
>
> —Atlantic.Net, Gainsville, Florida

Without proper management of technology and some re-organization in schools, attempts to integrate technology with the curriculum may be short-lived.

> *A critical element of technology integration and use of computers in schools is the management of both the hardware, software and human resources. My experience working with teachers and students as a technology curriculum consultant over the past three years has shown that many elements of the school organization need to be examined and modified. There is a wide variation in the level of management of technology among schools. It may be critical to examine whether there is a relationship between this factor and the level of curriculum integration. In order to determine the status of current efforts at technology integration in schools, a survey should be done to ascertain not just the number of computers that are presently in schools, but also how they are being used.*
>
> —Teaching Matters, Inc, Brooklyn, New York

The following quote offers future directions for research, development and evaluation raised by others in the quotes above:

> *(1) the efficacy of the technology for the student and teacher, (2) applicability to educational program requirements, and (3) issues of longevity and up-grade-ability of the hardware and software.*
>
> —Individual from Stephen F. Austin State University, Nacogdoches, Texas

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The following comments were submitted by the Association of American's Public Television Stations (APTS) a nonprofit organization whose members comprise nearly all of the nation's 352 noncommercial educational television stations. APTS' services to member stations include engaging in planning and research activities on behalf of its members; representing public television stations in legislative and policy matters; and generally providing information to assist public television stations in the pursuit of their missions.

> APTS submits the comments below to inform the Department of Education's Educational Technology division about public television's integral – but largely unknown – role in the research and development of technology applications for teaching and learning. Public television has undertaken such applications consistently and with fervor, as community education is major component of the public television mission. APTS anticipates that such activities will only increase, as member stations plan for the 2003 digital conversion. Stations look forward to maximizing this new age's promise by maximizing the components it already has in place: a ubiquitous, free signal; a strong, revered history of creating communities of learners; access to the newest that technology can offer; and longstanding partnerships with educational entities and other community stakeholders.

Public television is a key player in both researching applications for educational technologies and in developing these applications, creating digital solutions to enhance broadcast television and bringing the wealth of public television's educational content onto the internet. Such activities are not unique, but are a staple of public television's mission and commitment to quality education. Indeed, public television could not retain its role as a leader in technology-based education were it not undertaking activities such as those outlined below:

- **An innovative development forum for new technologies:** KCPT'S new Digital Convergence Laboratory is a multifacted research and development center for new educational technology, serving the community through: 1) a "Discovery Room" where educators and students can experiment with the newest technologies, in a hands-on forum; 2) a speaker series, featuring industry leaders on Digital TV and new media; 3) an internal web resource for educators; and, 4) an Ambassador program, sponsoring inner city High School students to work as interns at the laboratory and take their new knowledge back into their schools as DCL ambassadors.

- **Research on Delivering Instructional Video-on-Demand:** In 1998-99, the Wisconsin Educational Communications Board conducted a research project to plan for reliably and inexpensively delivering instructional video programs and segments to PK-12 classrooms on demand. The project, funded through NTIA's PTFP program, explored multiple alternative strategies for delivering video-on-demand, based on the different capabilities of datacasting and multicasting through digital television and the opportunities presented by the internet. Researchers concluded that "Of the alternative strategies presented, datacasting comes closest to meeting the parameters agreed upon to govern the project. Entire instructional video programs and segments excerpted from these programs can be encapsulated into data files for rapid transmission. These files may be piggy-backed on the digital television signal carrying either a high-definition TV program or up to four standard definition programs as they are broadcast into Wisconsin schools and homes."

- **Partnerships with research facilities:** The University of North Carolina's Frank Porter Graham Child Development Center is an internationally acclaimed expert on child development issues. In 1998, the Center partnered with University of North Carolina Center for Public Television (UNC-TV) and the public/private entity Smart Start in an effort to develop distance-learning projects that would provide credentialing opportunities for North Carolina's largely undereducated child care providers. While funding is still being sought, this partnership remains in place, and the proposed program, which utilizes a Web-TV interface to deliver courses via UNC's statewide signal, is a model of television-based solutions in a era of digital divides.

Public television stations are key players in developing new applications for educational technology, and leaders in developing the educational possibilities of multicasting and datacasting. While such efforts and partnerships have been undertaken consistently, they remain unknown to many – even those inside the educational arena. APTS invites the Office of Educational Technology to enhance its knowledge of the vast array of research and development initiatives already in place. We look forward in joining OET in pursuit of our common mission.

Summary Report of Comments on E-LEARNING AND EDUCATION

Background

Since the 1996 release of the nation's first educational technology plan, interest in increasing the use of technology in education has catapulted to national prominence. This interest has been spurred by the widespread recognition of the transformations technology is having on the American economy, as well as by the potential for technology to transform the teaching and learning experience. A growing sense now exists that there is a critical mass of opportunities to make tremendous strides in improving the nation's schools. In recognition of these opportunities, the Office of Educational Technology has undertaken a strategic review and revision of the national educational technology plan to be completed by fall 2000.

As part of the process of preparing the plan, the U.S. Department of Education's Office of Educational Technology is soliciting public comments on priorities for the future of technology in education, originally identified at the *Forum on Technology in Education: Envisioning the Future*. These priorities include issues related to: access to technology, teachers and technology, students and technology, e-learning, and research and development.

This report summarizes the comments received on the priority of e-learning and education, which were received through a website constructed for that purpose (see www.ed.gov/Technology for more information). It is divided into three main sections:

1. **E-learning and its impact on teaching**. These comments address both the changing role of teachers and the classroom environment with the advent of e-learning.

2. **E-learning and its impact on students.** These comments focus on new learning tools and their impact on students and learners of all ages. These comments also address other issues that are important to consider as the e-learning market continues to grow and develop.

3. **E-learning and its impact on schools**. These comments address what e-learning means for schools. Also included in this section is a list of recommendations for educators and policymakers from the Center for Internet Technology in Education (CITE).

The following sections include more specific information, both paraphrased and directly quoted, from those individuals who provided feedback.

E-Learning and Its Impact on Teaching

> *The Internet is fast becoming an engine of innovation in education. As it is revolutionizing business through e-commerce, the Internet is on a course to redefine education. E-learning, or the delivery of education and related services over the Internet, is being touted as the next most innovative application of the Internet, and private investment in education organizations is rapidly expanding. Fostering innovation in education – from the provision of digital learning, digital content, assessment services, tutoring, distance learning, data warehousing, and other forms of instructional technology – is important. Other areas ripe for innovation included ways of: establishing collaboration among schools, libraries, museums, higher education, and industry; evaluating the quality of educational materials and content; and, archiving public domain historical, cultural, and scientific resources.*

E-learning is vastly transforming the nature of education resulting in major changes in the role of teachers and the relationship between teacher and student. Despite the many benefits and advantages of e-learning in general, information obtained over the Internet must still be evaluated for its instructional value. E-learning should be viewed as a way to augment student's critical thinking and analysis skills.

> *Good teaching before the age of computers is good teaching still…. The Internet and everything else emanating from computers will be helpful only if examined and questioned critically. Teaching this critical thinking may well be our greatest challenge.*
>
> —Individual from Peekskill, New York

> *Technology will greatly improve communication skills and make information easier to obtain* [however] *we will still have to analyze and evaluate information as to its truth and relevance.*
>
> —Teacher, Tulsa Public Schools, Oklahoma

Improvements in the delivery of professional development will also occur through the advent of e-learning, as teachers will be able to participate in professional development activities from anywhere across the country. Opportunities for collaboration between instructors will also increase.

> *We are reorganizing how we deliver instruction through the use of live web-based collaboration technologies that allow us to hold live on-line classes with teachers across the U.S.. Professional development organizations like ours will be able to meet teachers when and where they need us and spend less time telling teachers what they need to know and more time helping them to share information with each other.*
>
> —Individual from Teaching Matters, Inc., New York

The following individual critiques the structure of current teacher education programs asserting that faculty in these programs are currently not instructing teachers about e-learning and the wide array of educational resources available through the Internet. As a result, teachers are often ill prepared for the new "tech-driven" educational environment:

> *Teachers are learning about technology through remedial in-service workshops because they are not learning how to use technology in their pre-service teacher preparation programs. It would seem more cost-effective to train thirty teacher educators who in turn teach hundreds of future and practicing teachers then to teach the same number of teachers who may or may not teach anyone else to use technology. Teacher preparation programs should be models of the future, not relics of the past.*
>
> —Individual from State University of New York at Potsdam, New York

The Association of America's Public Television Stations (APTS)[1] suggests that there might also be other suitable formats for e-learning in addition to the Internet. For example, they believe that:

> *Public television is uniquely situated to maximize synergistic possibilities presented by digital television, while also developing online resources and streaming video on the Internet.*
>
> —Association of America's Public Television Stations (APTS)

As these comments suggest, more consideration needs to be devoted towards the changes occurring in education as a result of e-learning and the meaning of these changes for teachers and students.

> *The nexus of learning is between the teacher and student, not out somewhere on the net. What is needed are simulation, collaborative, virtual environment, intelligent tools with full support for professional development that will transform the learning experience.*
>
> —Individual from Arizona Learning Technology Partnership, Phoenix, Arizona

E-learning and Its Impact on Students

E-learning in addition to its impact on teachers and teaching is also affecting students and learners of all ages by changing the nature of the learning environment. E-learning, which promotes anytime, anywhere learning, is a solution for today's world in which life-long learning is fast becoming a necessity with time—or lack there of—a persistent problem for all.

The following quote reflects on some of the advantages of e-learning over traditional, face-to-face instruction:

> *E-learning is definitely an alternative way to help children and adults pursue educational excellence. As an adult, I am taking internet-based courses which give me a designated time to respond to the course outline. I can complete and submit work at 3am if I so choose. I can establish a "chat time" with students in the class. Homework is posted on-line and always date and time stamped. I can enroll in any campus that offers an on-line course regardless of the actual city/state. E-learning opens access to learning 24 hours a day.*
>
> —Individual from Imaginuity Interactive, Dallas, Texas

Furthermore, with the help of innovative programs available through e-learning students are learning in new ways and, in many cases, producing amazing results. The following individual discusses a project recently completely by an elementary school class in the South Bronx, New York:

> *A fifth-grade class authored a website about Shakespeare's Macbeth based on their own production of the play. The class worked together to create hyperlink annotations to an electronic copy of the text that they had performed. This website contains over 50 hyperlinked annotations to the text, 28 full-color illustrations, 19 character biographies, the story of Macbeth in the students' own words, and more. It can be seen at the following address: http://member.aol.com/shakspere/macbeth.html/ The Internet has great potential in the classroom, not lonely to deliver education and related services, but also to serve as a publishing medium for student work.*

—Individual from Teaching Matters, Inc., New York

Knowing how to think critically and evaluate information to determine both it's accuracy and relevancy is becoming increasingly important as students turn to the Internet for answers to their questions and assistance in completing projects. The following statement elaborates on this:

> *I believe it is essential that students become active, critical thinkers in all aspects of their lives, but especially when trying to make sense of what is available online. I see the Internet as a massive library with no central cataloging system, requiring users to implement their own strategies for finding and quickly assessing information resources. Students need the problem-solving tools to help them find what they are looking for and to determine whether it is relevant to their current needs.*

—Teacher, Teaching Matters, Inc., New York

As the e-learning economy expands with an increase in both the quantity and quality of products and services, access for all will be imperative. Schools need to consider creative solutions for placing computers in the homes of poorer students whose families cannot afford them. Failure to do so may only widen the gap between the haves and have-nots:

> *As we keep hearing of the digital divide, I see the problems in our area of low income semi-rural communities that are in the mist of large housing developments. It looks that the haves and the have nots—is obvious. If we want to give the kids—our future— a fair chance of having what it takes to compete in the "New World" we better do something now.... My students went from PC's in the classroom to Macs in the school's lab. The only little problem is that they didn't have a computer at home to practice key-boarding or researching, or e-mailing--so what's an educator to do? Get [computers] in their hands. Check outs from the library, sign student and parent contracts to take care of them or replace any lost property--just like any book or text. Write grants to get these and do a little research to see that comes of these types of efforts.*

—Teacher/student, Salinas, California

According to the teacher in the statement below, until the appropriate resources are available to everyone, which in realty may still be a long way off, e-learning should not supplant traditional classroom-based instruction as it will only widen the digital divide:

> *....In lower-income areas, the support does not exist at home, and for many students the support network will not support e-learning. This factor alone makes it imperative that we not use e-learning to separate further the "haves" from the "have nots." Unfortunately, I have not seen many proposals as to how to reach this group of "have nots". Indeed, one could suggest that this group is always the hardest to reach, even with traditional classroom approaches. My fear is that these students will be warehoused away from the tremendous opportunities.*
>
> —Teacher, Woodland, California

Access entails not only having computers, but also being able to use the information available through computers:

> *Our richest historical resources -- Primary resources, documents, artifacts and the like -- are often made inaccessible by language and interfaces that are not friendly to those with a limited grasp of English. My dream is access-for-all through sensitivity to the potential audience, and the needed man-hours to make that possible. My dream is also for stronger, more accurate translating engines (i.e. Altavista's Babelfish) that help bring the more sophisticated resources of the Internet not only to America's ESL children, but also to the rest of the world.*
>
> —Individual from Teaching Matters, Inc., New York

Although many will agree that e-learning has several advantages to traditional classroom based learning the question remains, is it suitable for everyone? The following individual is skeptical about the appropriateness of e-learning for everyone:

> *It is important to remember when working with E-Learning that it won't work for every student, nor every community. While e-learning is perfect for some purposes, it cannot replace traditional classroom-based instruction for most students...That said, for certain students, such as those living in remote areas or those with disabilities that prevent their attending traditional schools, e-learning provides a perfect alternative. In addition, video-based e-learning, where a student takes a course his/her school does not offer, can work for some students.*
>
> —Teacher, Woodland, California

E-Learning and Its Impact On Schools

With the development and growth of the e-learning market schools may be forced to re-think their organization and classroom structure to accommodate the innovative delivery of course content. Additionally, universities will need to "determine their place," in the new-world of e-learning, as stated by the individual below:

> *Demands from Business and Industry will drive the initial development of e-learning and require that "traditional" institutions respond or be left in the dust. To compete, universities must determine their place within the education continuum (electronic and on-campus) and actively pursue that place. Institutions need to consider combined-method (asynchronous, synchronous, face-to-face) educational programming to address the content and types of learning.*
>
> —Stephen F. Austin State University, Nacogdoches, Texas

Furthermore, additional research into the design of distance learning programs, as well as the best means for delivering course content via computers and other technologies, should be conducted:

> *What still plague these efforts are not the use of technology, but the lack of instructional design to facilitate DE* [distance education]*…. Protocols need to be developed that foster student-student and student-instructor interaction. Strategies like panel discussions, group collaborative work, portfolio projects, debates, and case studies need be employed in DE. The "sage on the stage" needs to become the "guide on the side". Talking heads and static web pages must go. We must engage the learner in complex analysis and critical thinking.*
>
> —NASA/Virginia Tech, Blacksburg, Virginia

Of course there is also a downside to having access to all information. The following quote serves as a precaution to schools in general:

> *The Internet is indeed a marvelous tool; however, if care is not taken, it can be easily abused. It will not be possible to monitor educational web sites, but some strict guidelines pertaining to school web sites should be considered. Also, if care is not taken, the school web pages may be invaded with commercial types of information. This commercialism should be restricted from finding its way into the classroom computers, if possible.*
>
> —Retired public school teacher, Colorado Springs, Colorado

The following is list of recommendations, submitted by the Center for Internet Technology in Education (CiTE), of things to consider as the application of on-line technology both in the classroom and at a distance continues to grow:

- Aggressive and well-funded staff development programs should be created to support teachers in the effective use of Web-based technologies.
- State-level policy makers and legislatures should be encouraged to implement policy changes to address inequities in funding structures for Web-based education programs.
- Institutions that develop and facilitate Web-based education programs should have access to federal funding for the development of their programs.

- Educational policies should be created and supported that allow for equal access for all citizens to a high-quality learning environment and education.

- There should be established criteria for excellence in the design and delivery of Web-based education.

- Once criteria are established, there should be no distinction of merit between those who teach online and those who teach face-to-face, nor should there be a distinction between those who learn through either option.

- Students, teachers and educational administrators should maintain a high-quality online education environment.

- Educational institutions should be encouraged to offer supplemental online components to their traditional face-to-face learning environments.

- Web-based education brings anywhere-anytime access to education. Our national policy should reflect the rapidly changing Web-based education environment and the best ways to adapt to it.

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[1] The following comments were submitted by the Association of American's Public Television Stations (APTS) a nonprofit organization whose members comprise nearly all of the nation's 352 noncommercial educational television stations. APTS' services to member stations include engaging in planning and research activities on behalf of its members; representing public television stations in legislative and policy matters; and generally providing information to assist public television stations in the pursuit of their missions.

> *APTS submits the comments below to inform the Department of Education's Educational Technology division about public television's active and visionary role in educational activities that include a web component. Public television is paving the way for the best in multi-media applications in cities across the United States, and has positioned itself for the digital future, when multicasting and datacasting will only enhance its current activities. Moreover, public television's existing partnerships with educational and telecommunications entities, coupled with its ubiquitous infrastructure, will be integral to all seeking to maximize technology-based educational opportunities in the digital age.*

Public television is taking the lead in multi-media education. In an April 2000 CPB study of educational services by public television stations around the country, most successful initiatives included more than one mode of delivery, and more than half of these included online delivery. Public television's vision for educational initiatives already extends beyond broadcast television. The transition to digital television opens up a wealth of new possibilities -- possibilities that public television is already exploring.

- In Kansas City, America's Instructional Television Online (AITOL) is a prototype for instructional television on the web. www.mkn.org/aitol Developed with a focus on classroom users and keyed to state teaching standards, the AITOL project will support the encoding of KCPT's entire instructional video collection to a digital format. This will permit streaming of the video to both the classroom teachers and the students computer desktops. The project also includes a Digital TV instruction handbook (soon to be available online as on-demand streamed video), gathering resources for teachers to effectively use new educational technology, in one conveniently accessed location. The handbook contains descriptive information about each educational program, a teacher guide, lesson plans developed by classroom teachers, a two minute preview clip for each program, and verified web links to high quality sites that correlate with the video, as well as 'Just in Time' teacher professional development modules that highlight effective use strategies of the videos.

- For the past eight years, WXXI has partnered with the Rochester Teacher Association to produce Homework Hotline, an hour long program broadcast live during the school year at 6 PM to encourage parental involvement in children's education. Homework Hotline serves 9,000 students in the Rochester area, and now includes an online site, hosted by Edutech at http://nystandards.edutech.org/Homework/homework.htm.

- WGBH Interactive is a leader in capturing the dynamic union of enhanced television and online learning. http://www.wgbh.org/wgbh/learn/

It is unclear that the most effective forum for E-Learning is the internet alone. Television's digital transition will enable educational datacasting, bringing the wealth of the internet's data transmission to the ubiquitous infrastructure of broadcast public television, and pairing it with a time-proven system for delivering instructional video. Public television is uniquely situated to maximize the synergistic possibilities presented by digital television, while also devebping online resources and streaming video on the internet.

Introduction

Revising the 1996 National Educational Technology Plan

- NEW Two new white papers on the topics of "e-learning" and technology and disability
- NEW Updated priorities
- NEW Summaries of on-line input

Since the 1996 release of the nation's first educational technology plan, interest in increasing the use of technology in education has catapulted to national prominence. This interest has been spurred by the widespread recognition of the transformations technology is having on the American economy, as well as by the potential for technology to transform the teaching and learning experience. A growing sense now exists that there is a critical mass of opportunities to make tremendous strides in improving the nation's schools. In recognition of these opportunities, the Office of Educational Technology has undertaken a strategic review and revision of the national educational technology plan to be completed by fall 2000.

Please take the opportunity to learn more about this initiative and comment on the effective use of technology in education:

- Report on the Forum on Technology in Education: Envisioning the Future – Participants at the Forum explored technology trends and their implications for education toward the end of identifying new national priorities for technology in education. This report summarizes activities at the Forum, as well as several white papers prepared to inform discussions.
- White Papers on the Future of Technology in Education – A total of nine white papers have been commissioned to explore issues related to the future use of technology in education.
- Forum on Technology in Education: - Envisioning the Future –Individuals at the Forum explored the implications of the white papers and participated in interactive exercises to envision a future of education brought about by the effective use of technology.
- Emerging Priorities – Originally identified by participants at the Forum, these issues are likely to be pivotal in any successful effort to increase the effective use of technology in education.
- Your Comments – View summaries of comments received on the revision of the national educational technology plan.

Learn more about the 1996 national educational technology plan *Getting America's Students Ready for the 21st Century*

Introduction | Forum Report | Forum White Papers | Forum on Technology in Education | Emerging Priorities | Comment Here | 1996 National Educational Technology Plan

'96 ET Plan

The 1996 National Educational Technology Plan

> "We know, purely and simply, that every single child must have access to a computer, must understand it, must have access to good software and good teachers and to the Internet, so that every person will have the opportunity to make the most of his or her own life."
>
> President Clinton

On February 15, 1996, President Clinton and Vice President Gore announced the Technology Literacy Challenge, envisioning a 21st century where all students benefit from the use of educational technology. The challenge was placed before the nation as a whole, with responsibility for its accomplishment shared by local communities, states, the private sector, educators, parents, the federal government, and others. At the heart of this challenge were four concrete goals that help to define the task at hand:

- All teachers in the nation will have the training and support they need to help students learn using computers and the information superhighway.
- All teachers and students will have modern multimedia computers in their classrooms.
- Every classroom will be connected to the information superhighway.
- Effective software and on-line learning resources will be an integral part of every school's curriculum.

In support of the Technology Literacy Challenge, Secretary of Education Riley released the nation's first national educational technology plan in June of 1996, *Getting America's Students Ready for the 21st Century: Meeting the Technology Literacy Challenge*. Since that time, tremendous progress has occurred toward achieving those goals. The National Center for Education Statistics (NCES) reports, for example, that in 1994, only 35 percent of public elementary and secondary schools, and 3 percent of all instructional rooms, had access to the Internet. Today, 95 percent of public schools and 63 percent of instructional rooms have access to the Internet (NCES, 2000).

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